The Handbook of Wykeham Farrance GeoTriax

Georgopoulos Ioannis-Orestis[1]
Vardoulakis Ioannis[2]

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[1]PhD Student, NTU Athens, Greece
[2]Professor, NTU Athens, Greece

Nobody believes the numerical results, but the numerician himself.
Everyone believes the experimental results, but the experimentalist.

To my beloved parents and sister
Sarantos, Panoraia and Eleni

Figure 1: Arthur Casagrande

Arthur Casagrande was born in August 28, 1902 and educated in Austria. He immigrated to the United States in 1926. There he accepted a research assistantship with the Bureau of Public Roads to work under Terzaghi at M.I.T. While at M.I.T., Professor Casagrande worked on soil classification, shear testing, and frost action in soils. In 1932 he initiated a program in soil mechanics at Harvard University. Professor Casagrande's work on soil classification, seepage through earth structures, and shear strength has had major influence on soil mechanics. Professor Casagrande has been a very active consultant and has participated in many important jobs throughout the world. His most important influence on soil mechanics, however, has been through his teaching at Harvard. Many of the leaders in soil mechanics were inspired while students of his at Harvard. Professor Casagrande served as President of the International Society of Soil Mechanics and Foundation Engineering during the period 1961 through 1965. He has been the Rankine Lecturer of the Institution of Civil Engineers and-the Terzaghi Lecturer of the American Society of Civil Engineers. He was the first recipient of the Karl Terzaghi Award from the ASCE.

Contents

Preface **ix**

1 The Wykeham Farrance loading frame (WF10056/SN:100175-7) **1**

2 The Wykeham Farrance triaxial cell (WF11001/SN:100257-9) **7**
2.1 The base plate of the WF triaxial cell 9
2.2 The WF chamber 19

3 The WF volume change apparatus (WF17044/SN:107584-7) **33**
3.1 Introduction 33
3.2 Installation 34
3.3 Control Module Valve Positions 35
3.4 Calibration 35

4 The Data Acquisition System (WF-GeoDaq) **41**
4.1 The terminal box 41
4.2 The analog/digital input/outup card 46
4.3 The data acquisition program 49

List of Figures

1 Arthur Casagrande 7

2 The GeoLab WF Triaxial Apparatus x

1.1 Wykeham Farrance 50kN typical triaxial loading frame (photo taken from WF web site) 2
1.2 Wykeham Farrance 50kN triaxial frame (photo) 3
1.3 Wykeham Farrance 50kN triaxial frame front panel (photo) . 4
1.4 Wykeham Farrance 50kN triaxial frame rear view (photo) . . 4
1.5 Wykeham Farrance 50kN triaxial frame (side and top view) . 5
1.6 Calibration of Wykeham Farrance 50kN triaxial frame (WF10056/SN:100175-7) displacement rate (upwards direction) 6

2.1 Wykeham Farrance (WF11001/SN:100257-9) triaxial cell . . 8
2.2 Side and top view of Wykeham Farrance (WF11001/SN:100257-9) triaxial cell 8
2.3 Wykeham Farrance base plate WF11001/SN:100257-9 9
2.4 Top and side view of Wykeham Farrance base plate WF11001/SN:100257-9 10
2.5 Cell pressure line (Port1) 11
2.6 RS Type 249-S086219-Cell Pressure-Port1 Calibration, 2004-07-04 12
2.7 RS Type 249-S086219-Cell Pressure-Port1 Calibration, 2004-11-23 12
2.8 Pore pressure line (Port2) 13
2.9 2200AGB1001A2UA003-Pore Pressure-Port2 Calibration, 2004-07-05 14
2.10 2200AGB1001A2UA003-Pore Pressure-Port2 Calibration, 2004-11-23 14
2.11 Cell pressure line (Port3) 16
2.12 2200AGB1001A2UA003-Cell Pressure-Port3 Calibration, 2004-07-05 16
2.13 2200AGB1001A2UA003-Cell Pressure-Port3 Calibration, 2004-11-23 17

2.14 Pore pressure line (Port4) 17
2.15 RS Type 249-T023096-Pore Pressure-Port4 Calibration, 2004-07-05 18
2.16 RS Type 249-T023096-Pore Pressure-Port4 Calibration, 2004-11-23 18
2.17 Typical curve of volume change of a triaxial chamber versus cell pressure (Head) 19
2.18 Calibration of WF11001/SN:100257-9 triaxial cell under isotropic pressure 20
2.19 De-airing valve on top of WF triaxial cell and strain arm post 21
2.20 Wykeham Farrance axial displacement transducer reference manual, LSC-HS50-9021 22
2.21 Wykeham Farrance axial displacement transducer calibration, 2004-06-01, LSC-HS50-9021 23
2.22 Wykeham Farrance axial displacement transducer calibration, 2004-07-10, LSC-HS50-9021 23
2.23 Wykeham Farrance axial displacement transducer LSC-HS50-9021 24
2.24 Friction developed in the sliding contact of the piston with the triaxial bush 25
2.25 DBBSE-50kN-A2242 external load cell (Applied Ltd) 26
2.26 DBBSE-50kN-A2242 external load cell reference manual . . . 27
2.27 DBBSE-50kN-A2242 external load cell calibration, 2004-09-06 28
2.28 Wykeham Farrance STALC3-50kN triaxial submersible load cell 30
2.29 STALC3-50kN-24937 submersible load cell calibration, 2004-10-29 30
2.30 STALC3-50kN-24937 submersible load cell reference manual . 31

3.1 Wykeham Farrance volume change apparatus (photo taken from WF web site) 34
3.2 Wykeham Farrance volume change apparatus front panel, WF17044/SN:107584-7 35
3.3 Wykeham Farrance volume change apparatus displacement transducer reference manual, LSC-HS25-9016 37
3.4 Wykeham Farrance volume change apparatus displacement transducer calibration, 2004-05-25, LSC-HS25-9016 38
3.5 Wykeham Farrance volume change apparatus displacement transducer calibration, 2004-06-15, LSC-HS25-9016 38
3.6 Wykeham Farrance volume change apparatus displacement transducer, LSC-HS25-9016 39
3.7 Wykeham Farrance volume change apparatus, WF17044/SN:107584-7 39

4.1 The WF-GeoDaq System 42
4.2 External view of WF-GeoDaq terminal box 42
4.3 Internal view of WF-GeoDaq terminal box 42
4.4 Instructions for mounting the terminal box (1) 43
4.5 Instructions for mounting the terminal box (2) 44
4.6 WF-GeoDaq terminal box spare parts 45
4.7 Typical 'DIN' 5 pin 240^0 pole-type cable plugs 46
4.8 CB-68LP connector board 47
4.9 Analog/digital input/output data acquisition card (NI PCI-6024E) 47
4.10 The Labview v.7.1 interface 49

List of Tables

1.1 WF10056/SN:100175-7 triaxial loading frame specifications . 1
1.2 WF commands via RS232 serial port 2

2.1 RS Type 249-S086219-Cell Pressure-Port1 Calibration Table . 11
2.2 2200AGB1001A2UA003-Pore Pressure-Port2 Calibration Table 13
2.3 2200AGB1001A2UA003-Cell Pressure-Port3 Calibration Table 15
2.4 RS Type 249-T023096-Pore Pressure-Port4 Calibration Table 15
2.5 LSC-HS50-9021 Specifications-Calibration Table 21
2.6 DBBSE-50kN-A2242 External Load Cell Calibration Table . 26
2.7 STALC3-50kN-24937 Submersible Load Cell Calibration Table 29

3.1 LSC-HS25-9016 Calibration Table 36

Preface

The main purpose of this report is to present the Wyhekam Farrance[1] triaxial apparatus, found in the Laboratory of Geomaterials[2], Section of Mechanics, Faculty of Applied Mathematics and Physics, National Technical University of Athens. Its main parts, the loading frame and the cell, will be presented in details in the following sections.

Keeping this preface as short as possible, I would like to express my deep thanks to Mr. Michalis Chatzikabouris and Mr. Paris Xystris[3], whose technical support was more than precious during and after the successful installation of the described apparatus. I should also attribute my appreciation to Mr. Patrolekas Michalis[4] as far as the data acquisition software is concerned. Finally, but not last, the first of the authors would like to acknowledge the European Research Training Program RTN-DIGA (HPRN-CT-2002-00220) for its financial support during his nine months training period (15-01-2003/31-10-2003) in Institut National Polytechnique de Grenoble, as well as the financial support of Alexandros S. Onasis Foundation, through its three years PhD scholarship.

[1] http://www.wf.ac.uk
[2] http://geolab.mechan.ntua.gr
[3] NEOTEK Measuring and Testing Systems, Athens, Greece
[4] National Instruments, Athens, Greece

Figure 2: The GeoLab WF Triaxial Apparatus

Chapter 1

The Wykeham Farrance loading frame (WF10056/SN:100175-7)

In this chapter, the WF© loading frame will be shortly presented. The loading frame (WF10056/SN:100175-7) has a maximum compressive strength of 50kN. The maximum compressive strength of such an apparatus is mainly restricted by the tensile resistance of the two main columns, which support the upper beam, and by the step motor, which applies a constant strain rate of deformation to the specimen. Other specifications of the WF frame may be found in Table 1.1.

The step motor allows for upwards or downwards movement of the base plane of the frame, thus allowing for a constant rate of deformation. The motor may move in a constant rate, ranging from 0.00001 to 5.99999mm/min. A front panel allows the selection of the deformation rate via a thumbwheel

Triaxial frame specifications	WF10056/SN:100175-7
Height [mm]	1460
Width [mm]	503
Depth [mm]	380
Horizontal clearness	364
Vertical clearness (maximum) [mm]	1000
Vertical clearness (minimum) [mm]	335
Platen diameter [mm]	158
Platen travel [mm]	100
Weight [kgr]	98
Maximum power [Watt]	90

Table 1.1: WF10056/SN:100175-7 triaxial loading frame specifications

Function	Command (ASCII)
STOP	0
UP	1
DOWN	2
NEW SPEED	7

Table 1.2: WF commands via RS232 serial port

Figure 1.1: Wykeham Farrance 50kN typical triaxial loading frame (photo taken from WF web site)

strain rate control switch, two buttons for the upwards and downwards direction ("up" and "down"), one stop button ("stop") and two buttons for quick base plate adjustment ("fast up" and "fast down"). The current frame is also equipped with an RS232 serial port, which allows the user to control the triaxial frame via a personal computer. In order to accomplish the communication, the user has to setup the serial port to 9600 bits per second (Baud rate), data must be of 8 bit, no parity, flow control: none and 1 stop bit. Table 1.2 summarises the commands of the WF triaxial frame. The new speed command should be followed by a six digit speed value. For example, to stop and move the base plate in an upward direction selecting a new speed of 0.5mm/min, the following values should be send: 070500001.

In the following figures, photos and drawings of the WF-Triaxial Frame are given.

Figure 1.2: Wykeham Farrance 50kN triaxial frame (photo)

Figure 1.3: Wykeham Farrance 50kN triaxial frame front panel (photo)

Figure 1.4: Wykeham Farrance 50kN triaxial frame rear view (photo)

In Figure 1.6 the stepper motor of the loading frame is tested and calibrated against constant rate of the displacement of the base plate. The LSC-HS50-9021 and LSC-HS25-9016 displacement transducer are used to measure the displacement of the base plate of the loading frame.

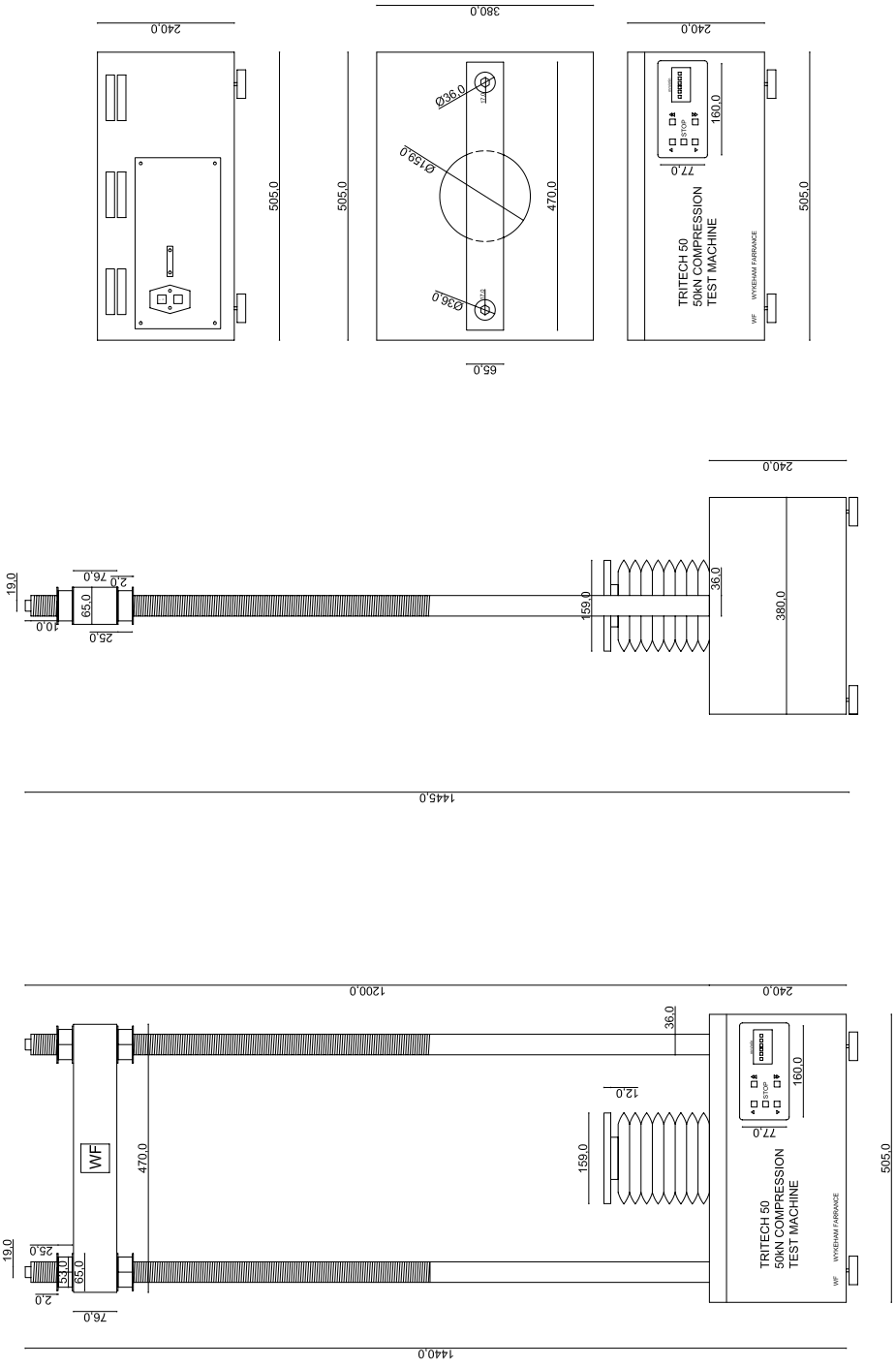


Figure 1.5: Wykeham Farrance 50kN triaxial frame (side and top view)

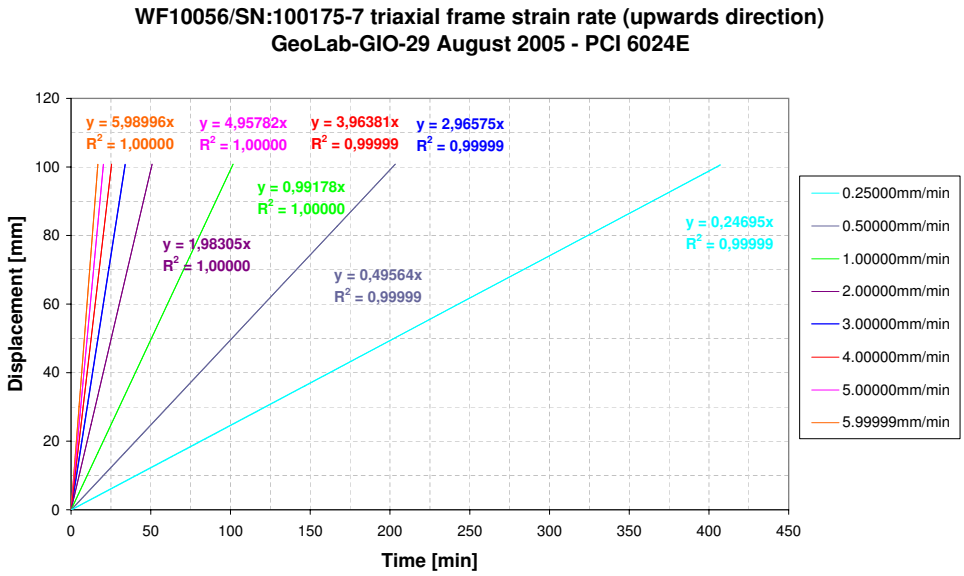


Figure 1.6: Calibration of Wykeham Farrance 50kN triaxial frame (WF10056/SN:100175-7) displacement rate (upwards direction)

Handbook for use with WF10056 TRITECH 50 triaxial load frame of 50kN Capacity

WYKEHAM FARRANCE ENGINEERING LIMITED
Weston Road
Trading Estate
Slough
Berks, SL1 4HW
England

Telephone 44 0753 571241
Telefax 44 0753 811313
Telex 847301 WFENG

TRITECH 50 MANUAL VERSION 1

CONTENTS

	Page No
1) INTRODUCTION	3
2) SPECIFICATIONS	3
3) INSTALLATION	4
4) CONTROLS/DESCRIPTION	4
5) TRITECH 50 FUNCTIONS	5
6) COMPUTER FUNCTIONS	6
7) MAINTENANCE	6

APPENDICES

Appendix (i) FAULT DIAGNOSIS	7
Appendix (ii) TRITECH BLOCK DIAGRAM	8
Appendix (iii) TRITECH CPU MODULE VERSION 1	9
Appendix (iv) TRITECH DISPLAY MODULE VERSION 1	10
TRITECH ASSEMBLY/WIRING DIAGRAM	

1)INTRODUCTION

The WF10056 TRITECH 50 Machine has been designed using the most up to date microprocessor controlled electronic drive unit and modern stepper motor technology.

The TRITECH 50 has been specifically designed for the testing of triaxial soil specimens. It will also perform compression and flexural tests over a wide range of materials up to it's maximum load of 50 kN.

The speed of the given test can be varied at any time during the test by the operator altering the thumbwheel switch on the front panel. The speed control of the TRITECH 50 is calibrated in mm/min (engineering units) which is indicated digitally. This enables the TRITECH 50 to be set by the operator accurately to any desired speed of operation, without the need for calibration charts.

The forces applied to the ram are operated by a ballscrew which is driven by a stepper motor via a spur gearbox. The travel limit of the ram is protected in both directions by limit switches which are internally fitted.

The up/down rapid control buttons allows the operator a means of quickly increasing or decreasing the platen level.

The crosshead beam is adjustable to accept a wide range of test apparatus up to a maximum compression load of 50 kN.

At the rear of the TRITECH 50 an RS232 port has been provided to enable the TRITECH 50 to be controlled remotely

2)SPECIFICATIONS

DIMENSIONS:	HEIGHT	1460mm
	WIDTH	503mm
	DEPTH	380mm
HORIZONTAL CLEARANCE		364mm
VERTICAL CLEARANCE (MAXIMUM)		1000mm
VERTICAL CLEARANCE (MINIMUM)		335mm
PLATEN DIAMETER		158mm
PLATEN TRAVEL		100mm
SPEED RANGE		0.00001-5.99999mm/min.n
WEIGHT		[redacted]
MAXIMUM POWER		90 Watts

Note:- Maxium/minimum vertical clearance is the measurement between the platens surface and the base of the crosshead beam.

3)INSTALLATION

Your TRITECH 50 machine was thoroughly inspected before shipping and is ready to operate as soon as the installation procedure has been completed. Notify Wykeham Farrance or your local agent and file a claim with any carriers involved if you find any damage, within 7 days of receipt.

Care must be taken when lifting the TRITECH 50. It should be positioned on a suitable rigid bench (which can be supplied by us WF10079) or other flat surface capable of withstanding the total weight of the machine including the weight of the sample. The machine is supplied with adjustable feet to compensate for any uneveness of the bench surface.

To ensure a long and trouble free life for your machine it is important that it is kept clean and that the louvres in the base and rear of the machine are kept clear of obstructions to allow a constant air flow through the machine.

Before powering up your TRITECH 50 check that the voltage selector is set so that it is compatible with your local supply voltage. This is done by lining up the arrows on the voltage selector/filter.

Once this has been done the integral power cable which is supplied with the unit may be connected to the TRITECH 50. The machine may then be operated through a standard 13 amp socket using a suitable three-pin plug with a fuse rating of 3 amps.

Colour	**Function**
Green/Yellow	Earth (Ground)
Blue	Neutral
Brown	[redacted]

It is essential that the plug fitted to the machine is wired correctly.

4)CONTROLS/DESCRIPTION

4.1 MAINS:

The power on/off switch is located at the rear of the TRITECH 50. When it is switched 'ON' the STOP Lamp is illuminated ie., (ON = '1', OFF = 'O').

4.2 SPEED SELECTOR SWITCH:

The thumbwheel Speed Selector switch displays digitally the platen travel in mm/min. This speed can be altered between 0.00001 and 5.99999 mm/min. at any time.

4.3 UP/DOWN TRAVEL SWITCH:

If either the Up or Down switch is pressed the control board latches onto the signal and causes the platen to be raised or lowered at the selected speed.

Correct operation is indicated by a green flashing light inside the switch. If the platen reaches its limit the green switch indicator ceases to flash. When this condition occurs the STOP switch has to be pressed before another operation can be carried out.

4.4 RAPID TRAVEL SWITCHES:

By holding either of the rapid travel switches in their 'ON' state, the platen can be raised or lowered rapidly. The direction of travel is indicated by a green flashing light inside the switch. When the limit is reached this light will be constantly on. If the switch is released the red Stop light will be illuminated after a short period. The unit is then ready for its next operation.

4.5 RS232 25 WAY 'D' CONNECTOR

When the RS232 connector at the rear of the TRITECH 50 is connected to a computer this allows the machine to be completely computer controlled.

PIN NO.	TRITECH 50	COMPUTER	COMMENT
2	RX	TX	COMPUTER TRANSMIT DATA
3	TX	RX	COMPUTER RECEIVE DATA
7	GND	GND	SIGNAL GROUND

5)TRITECH 50 FUNCTIONS

It is recommended that before any test commences the platen is a minimum of 10 mm from the lower limit.

Before starting the test, set the crosshead beam to its correct position by adjusting the location nuts. To ensure that the beam is level, check it by direct measurement using a tape measure or by spirit level.

Assemble the test accessories in the load frame using rapid travel switch (▲) to adjust the distance between the cross beam and the platen.
Set the digital thumbwheel switch to the required speed.

To start the test press the up (▲)button. The correct operation and platen direction will then be indicated by the green flashing light inside the switch.

The platen speed may be altered at any time during the test.

Once the test has been completed the direction of platen travel may simply be reversed by pressing the stop button followed by the (▼) down button or rapid down button (▼▼).

If the supply voltage (power) to the machine is switched off duringa test, the machine may unload itself.

If correct operation of the TRITECH 50 does not occur check through each stage from power-up using the fault diagnosis chart. [Appendix: (i)].

6) COMPUTER FUNCTIONS

FUNCTION	COMMAND (ASCII)
STOP	0
UP	1
DOWN	2
NEW SPEED	7

The New Speed command should be followed by a six digit speed value. For example, to select 5.00000 mm/min send ASCII 7 (Command for new speed) and then 500000.

To select any of the TRITECH 50 functions above the user must send the appropriate ASCII commands via the serial port of a computer.

The data must be of 8 bit no parity and 1 stop bit and it must also be sent at a rate of 9600 bits per second (BAUD RATE).

7)MAINTENANCE

WARNING:
The unit must be switched off and disconnected from the mains power supply before dismantling the unit.

To ensure long life and trouble free usage it is suggested that the following procedure is adopted:-

1. Lightly oil platen surface each time the machine is used.

2. Lightly oil strain rod threads and load column ram every month.

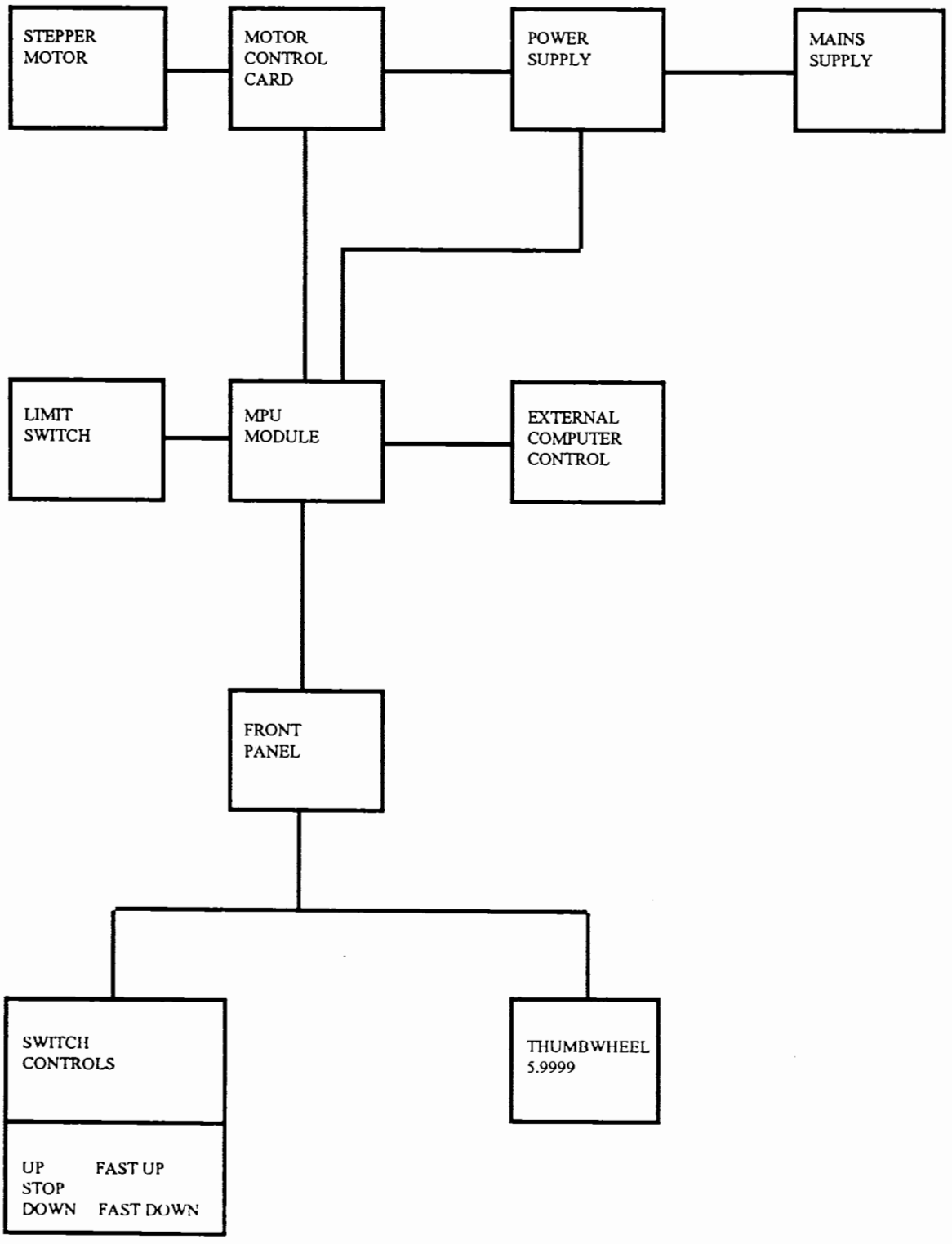
3. The spindle and ball screw should be lubricated at six monthly intervals. This is done by unscrewing the platen to expose a hole in the centre of the ram.

Appendix (i) FAULT DIAGNOSIS

SYMPTON	POSSIBLE CAUSE	CORRECTION
1) NO POWER UP	-Supply voltage incorrect	Supply correct voltage
	-Blown fuse	Replace fuse
	-Power lead disconnected	Connect power lead
	-Stop bulb blown	Change bulb
	-No supply voltage at front panel	Switch off supply voltage. Remove the front panel to inspect the inline power connector
2) MOTOR DOES NOT RUN	-Direction not selected	Press the up or down direction switch
	-Platen at its limit	Reverse direction
	-Short circuit blows fuse	Check motor connection
	-Card fuse blown or green LED not lit	Change motor drive card
	-Defective motor	Change motor
	-No pulse supply to motor	Change CPU card drive card
3) PLATEN MOVES BUT NO FLASHING LIGHT	-Blown bulb	Replace bulb
	-Faulty wiring	Inspect wiring loom
	-Faulty CPU card	Replace card
4) PLATEN MOVES AT INCORRECT SPEED	-Faulty thumbwheel switch	Replace switch
	-Faulty/loose connection	Check loom in the wiring loom
	-Incorrect pulsing	Change CPU card
5) INCORRECT COMPUTER OPERATION	-Wrong baud rate	Change baud rate
	-Computer communication	Check transmit/fault receive lines
	-Wrong parity set	Re-configure computer

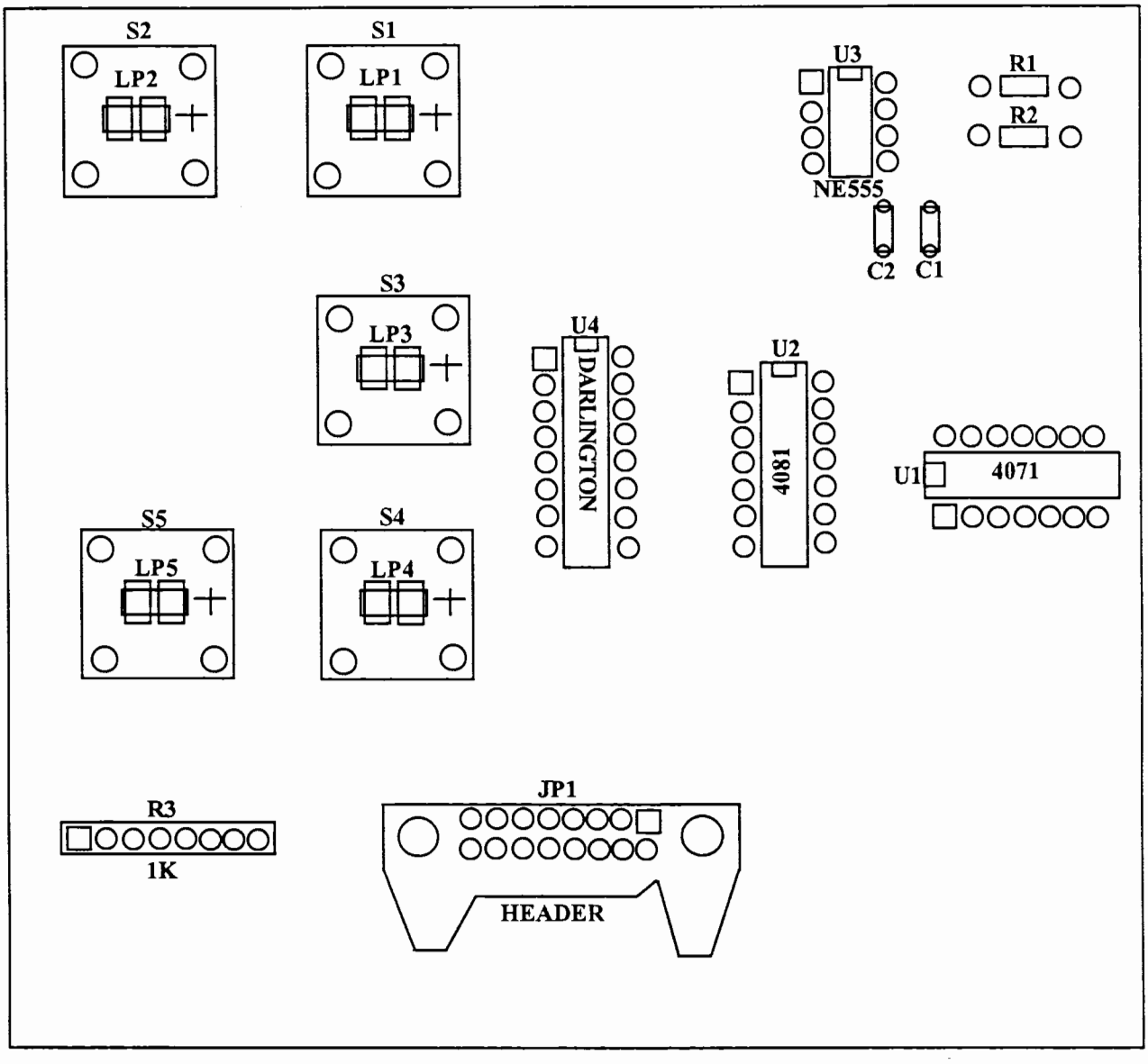
If a problem remains contact your dealer or WYKEHAM FARRANCE CUSTOMER SERVICE DEPARTMENT.

Appendix (ii) TRITECH BLOCK DIAGRAM

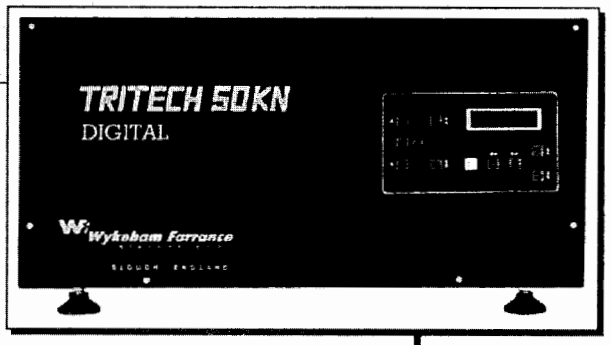


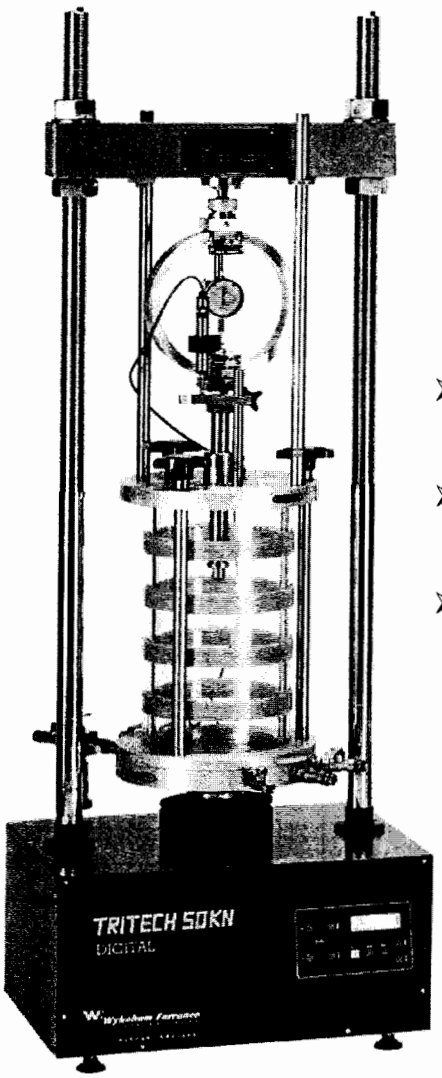
TRITECH - CPU MODULE VERSION 1
TRITECH
CPU Module V1.0
JP3 HEADER
JP2 HEADER
R3
1K R4
74HC14
U11
82C55
U6
S1
C10
R10
D1
R2
C7
U5
74C922
C5
JP1
HEADER
C6
JP7
62256 / 6254
U7
C8
74HC04
U1
C12
JP1 0v
27128 / 2764
U8
JP4
HEADER
C9
C16 C15
C13
C14
JP6
U10
74HC373
C11
LT1081
U12
U9
PAL16L8
C10
8088
U2
12MHZ
C4
C3
C2
Y1
JP5
JP8

Appendix (iv) TRITECH DISPLAY MODULE

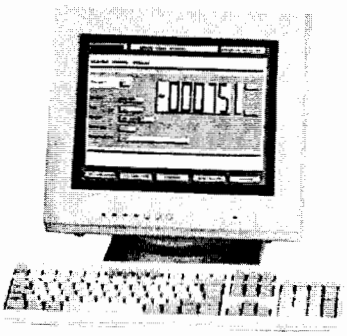


Wykeham Farrance
international





- **RS232 Control interface**
- **Digital control**
- **Speed range 0.00001 to 9.99999mm per minute**



Tritech 50
Triaxial Load Frame

The Tritech 50 is designed to be used as part of a computer-controlled triaxial system or as a stand-alone unit. The RS232 interface enables it to be used with any computer.

Combined with a logger the system can control the direction of travel, speed, rapid approach and unloading. The use of transducers will give electronic data acquisition and feedback to ensure accurate control of loading and strain in the sample.

A Total Solution Provider

Technical Specification

- **Rapid approach facility**
- **Audible alarm at limit of travel**
- **All steel construction, stainless steel platen**

Triaxial load frame 50kN
Speed range 0.00001 to 9.99999mm per minute
Digitally controlled with RS232 interface

Simple control buttons on the front panel provide fast/slow, up/down and stop commands for platen movement. A waterproof membrane seals the panel and digital display from water and dust.

A rapid approach facility is provided to reduce set-up time. The automatic datum facility returns the Tritech to previous settings when switched on and microswitches prevent platen over travel.

The load frame is of rigid chromed steel twin column construction, for rigidity at high loads. Stabilising bars are supplied as standard, to screw into the top of triaxial cells of 70mm diameter or larger, for added stability. All external parts are either stove enamel painted or chrome plated for corrosion protection. The loading platen is made from stainless steel.

Specification

Maximum sample size	105mm diameter
Minimum speed	0.00001mm per minute
Maximum speed	9.99999mm per minute
Maximum load	50kN
Minimum vertical clearance	335mm
Maximum vertical clearance	1000mm
Horizontal clearance	364mm
Platen diameter	158mm
Platen travel	100mm
Height	1460mm
Width	503mm
Depth	380mm

Ordering Information	**Part No.**
Tritech 50 kN Load Frame 240V 50Hz 1ph	10056
Tritech 50 kN Load Frame 110V 60Hz 1ph	10057

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Wykeham Farrance International
Weston Road
Slough
England
SL1 4HW

Tel: +44 1753 571241
Fax: +44 1753 811313
Email: sales@wfi.co.uk

TRITECH, Triaxial Load Frames

Standard
BS 1377:8 /ASTM D2850, D4767 / NF P94 070, P94 074

WF 10026

Tritech triaxial load frame 10 kN cap.
230-110 V, 50-60 Hz, 1 ph.

WF 10056

Tritech triaxial load frame 50 kN cap.
230-110 V, 50-60 Hz, 1 ph.

WF 10076

Tritech triaxial load frame 100 kN cap.
230-110 V, 50-60 Hz, 1 ph.

General description

The Tritech range of triaxial load frames has been designed to be used as part of a computer-controlled triaxial system or as a stand-alone unit. The RS 232 interface enables the Tritech to be used with any computer.
The control buttons on the front panel provide fast/slow, up/down and stop commands for platen movement. A waterproof membrane seals the panel and digital display from water and dust.
A rapid approach facility is provided to reduce set-up time. The automatic datum facility returns the Tritech to previous settings when switched on and micro switches prevent platen over travel.
The load frame is of rigid chromed steel twin column construction, for rigidity at high loads. All external parts are either stove enamel painted or chrome plated for corrosion protection. The loading platen is made from stainless steel.

WF 10056 with accessories

Tritech, Triaxial load frames (continued)

Technical specifications

Models	*WF 10026* **10 kN cap.**	*WF 10056* **50 kN cap.**	*WF 10076* **100 kN cap.**
Maximum sample size	75 mm dia.	105 mm dia.	150 mm dia.
Minimum speed	0.00001 mm per minute	0.00001 mm per minute	0.00001 mm per minute
Maximum speed	9.99999 mm per minute	9.99999 mm per minute	9.99999 mm per minute
Maximum load	10 kN	50 kN	100 kN
Minimum vertical clearance	440 mm	335 mm	390 mm
Maximum vertical clearance	880 mm	1000 mm	1040 mm
Horizontal clearance	278 mm	364 mm	550 mm
Platen diameter	158 mm	158 mm	158 mm
Platen travel	70 mm	100 mm	100 mm
Dimensions (HxWxD)	1240x363x320 mm	1460x503x380 mm	1700x703x503 mm
Power (W)	300	600	680

A stand is available for the 100 kN load frame.

Main features

- ***RS 232 control interface***
- ***Digital control***
- ***Speed range 0.00001 to 9.99999 mm per minute***
- ***Rapid approach facility***
- ***Audible alarm at limit of travel***
- ***All steel construction, stainless steel platen***
- ***The quality of the design has eliminated all vibrations that can affect the specimen under test***

The Tritech machines are versatile, compact and easy to use bench mounted load frames. They can be used for a variety of test procedures from simple uniaxial to the more sophisticated effective stress triaxial tests. The Tritech 10 unit provides a high quality testing capability at low loads.

WF 10026 with accessories

WF 10076 with accessories

Chapter 2

The Wykeham Farrance triaxial cell (WF11001/SN:100257-9)

The WF10056/SN:100175-7 loading frame is companied by a WF11001/SN: 100257-9 triaxial cell. The cell may house specimens up to 105mm in diameter. The cell pressure can reach up to 1700kPa. The cell is made of plexiglass, reinforced by a series of lateral plastic strips. The main body of the cell consists of two parts. The first one is the base plate of the cell, which lies on the moving base plate of the frame, while the second is the cell with the loading piston. Both parts are usually made of stainless steel so as to reduce the weight and increase their resistance to pressure and rust, in case the cell pressure is applied through de-aired water.

Figure 2.1: Wykeham Farrance (WF11001/SN:100257-9) triaxial cell

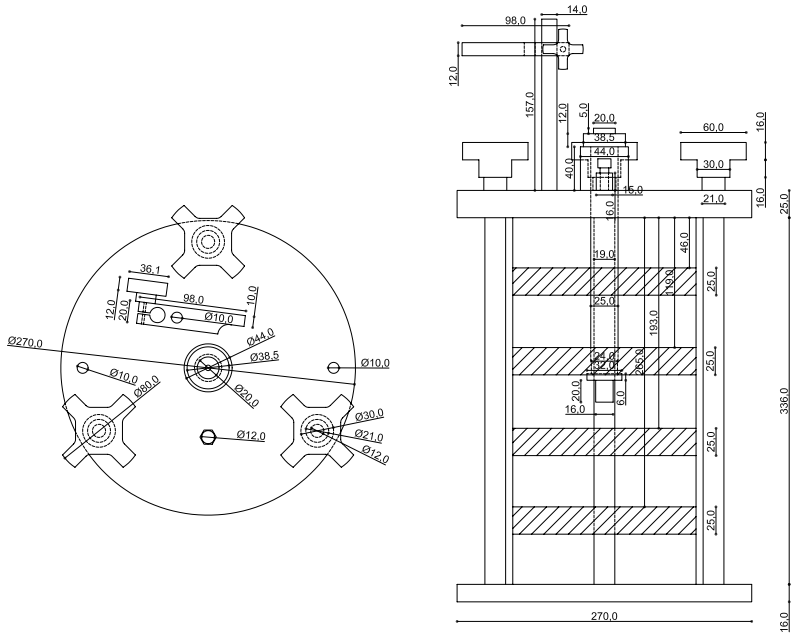
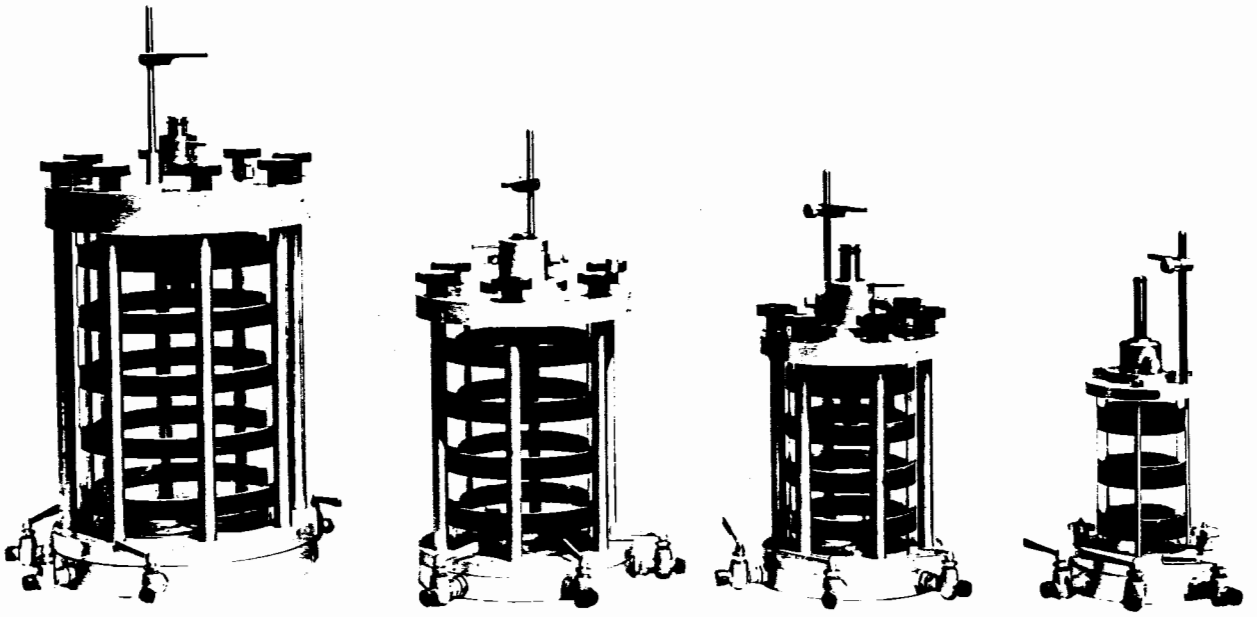


Figure 2.2: Side and top view of Wykeham Farrance (WF11001/SN:100257-9) triaxial cell

[redacted]



WYKEHAM FARRANCE ENGINEERING LIMITED
Weston Road,
Slough,
Berks.
SL1 4HW.

Telephone: (0753)571241

Telefax: (0753) 811313

Telex: 847301 = WFEN G

TRIAXIAL CELLS

1.0 INTRODUCTION

This instruction manual covers Wykeham Farrance Triaxial cells with the following part numbers:

WF10201

WF10751

WF10001

WF11144

The standard Wykeham Farrance Triaxial cells are manufactured primarily from a light alloy material of a non-corrosive specification. Each model of cell has detachable base platens (these are sometimes referred to as pedestals or pressure pads). Our catalogue shows the different platen sizes available for each cell together with part numbers of various ancillary items for each size. Platens of other sizes can be manufactured to order.

1.1 TYPES OF CELL

The ADVANCED RANGE cells have banded perspex chambers, the design includes valves and ports for back pressure and pore water pressure measurement. Two drainage ports are provided in the cell base, for back-pressures and porewater pressure measurements using transducers or null indicators.

The no-volume change valves, which are supplied as standard with the cells are of the pivot on/off type, having an external male thread of 3/8" BSP, with a conical female entry into the valve bore. Valve A (inlet-outlet valve) is counterbored to accept our quick release connection, but it will also accept the standard connections.

1.2 CONSTRUCTION

The various valves are indicated as follows:-

A. Inlet-outlet for chamber pressure (Cell Pressure)

B. & C. Bottom drainage for back pressure/pore water pressure

D. Outlet for top drainage

1.2.1 LOADING RAM

The loading ram or piston is precision engineered and is fitted into the cell with [redacted]low [redacted]. Great care must be taken to avoid damage to this ram. Do not at any time use abrasive cloths or powders to clean the bore or the ram. See Recommended Hints.

1.2.2 CHAMBER

To provide maximum visibility, the cell chambers are made from clear lucite-type material which is stress relieved by Wykeham Farrance during manufacture. This material can be adversely affected by certain environmental conditions, and note must be made of the recommendations given later concerning storage and care.

The chambers are designed [redacted]. The use of AIR as the chamber pressure medium without water is highly dangerous, and invalidates our Warranty.

Cells for samples up to 100mm (4.0 inches) diameter have cast perspex chambers, above this sample size fabricated perspex chambers are re-inforced with fibre-glass bands.

[redacted] 1760 [redacted]. For confining pressures above this figure, specially strengthened chambers must be used. However, the WF10751 and WF10754 cells are designed for operating pressure of 3500 kPa.

2.0 ASSEMBLY

The only assembly needed is to fit the following items:

(1) Strain arm post - this is simply screwed into place.

(2) The base platen and where necessary the top drainage cap.

2.01 The base platen is fitted using three hexagonal headed screws. On the upper side of the cell there is a centreing "pimple" or small projection. There is an equivalent hole on the underside of the base platen (the underside is the side with the 'O' ring seals). The "pimple" is located in the hole on the platen and the platen is then centred equally. The base of the cell is now turned over (make sure that the base platen is still centred). The hexagonal screws are now placed in the three holes until each is correctly seated. The screws are now tightened equally until tight.

2.02 TOP DRAINAGE

If you wish to use top drainage the blanking screw must be removed from the top cap and be replaced by the threaded connector, which should be screwed in to the top cap and gently tightened. The other end which has a nut must be gently screwed into the top drainage connector on the cell base.

2.03 Apply a little castor oil to the ram and gently push the ram up and down to distribute the oil evenly. The cell is now ready for use.

3.0 OPERATION

The following is a brief summary of the use of the various ancillary items that are used with the Triaxial cell and an outline of some of the more common test procedures.

3.01 TYPE OF STANDARD TEST

The triaxial tests which are used throughout the world vary, but generally they can be divided into two main groups.

1. UNCONSOLIDATED UNDRAINED COMPRESSION TEST.

2. CONSOLIDATED DRAINED OR UNDRAINED COMPRESSION TEST WITH EITHER VOLUME CHANGE OR PORE WATER PRESSURE MEASUREMENTS.

In this latter test the following additional accessories are required:

Porous drainage disks.

Top drainage.

Filter drains.

Pressure transducers or null indicator for pore water pressure measurement.

Volume change apparatus either electronic or manually controlled.

3.02 There is an extensive library of technical books describing triaxial test techniques in existence throughout the world, therefore this document does not cover test methods.

4.0 MAINTENANCE OF TRIAXIAL CELLS

Do not use abrasive materials to clean the ram. Do not allow the ram to become contaminated with dirt, clean regularly with a suitable product such as W.D.40 DO NOT allow any cleaning product to come into contact with the perspex chamber. After cleaning the ram with the W.D.40; the ram should be lightly oiled with a light machine oil such as 3 in 1 or with castor oil. [redacted] ON THE RAM AS THIS WILL OFTEN PREVENT THE RAM FROM FREE MOVE- [redacted] should slide down under its own weight.

4.1 PERSPEX CHAMBER

The perspex chamber may be cleaned with a weak soap solution.

4.2 RECOMMENDED HINTS

NEVER over-tighten the fixing nuts on the rods which clamp the cell top and ring to the chamber.

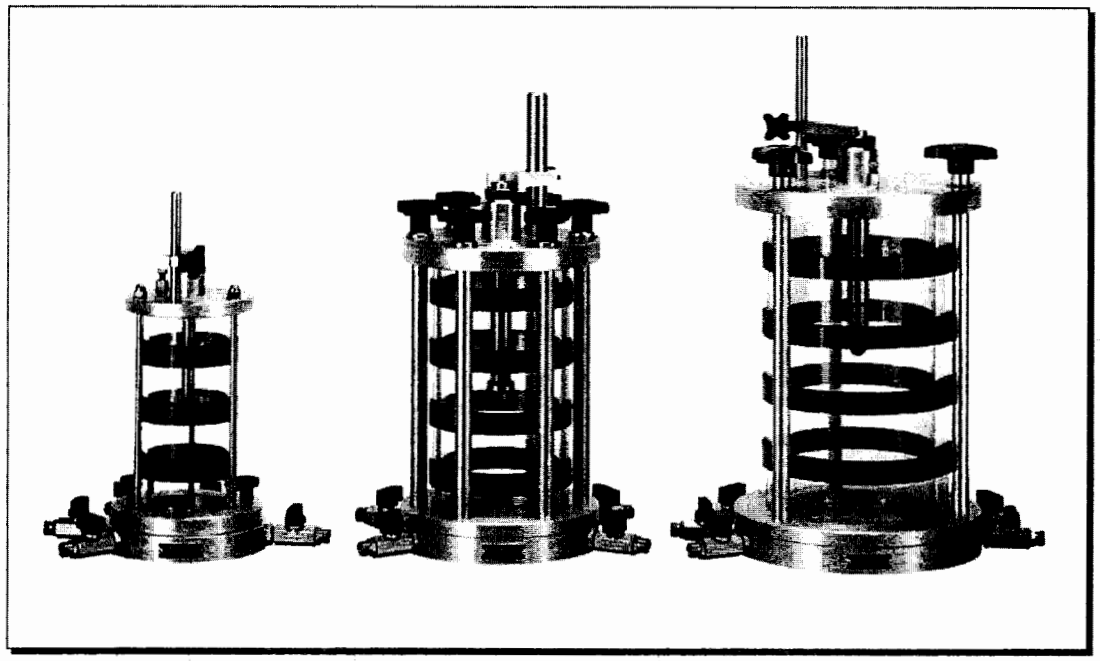
The ram and bore are closely honed fits and must be protected whenever possible. Prior to all tests, the water surface inside the chamber must always have a small amount of CASTOR OIL upon it which is fed into the cell via the oil inlet valve on the cell top. Thus when surplus liquid is in the cell, the oil is forced between the ram and the bore. We recommend castor oil in preference to all other oils.

If the ram and bore become fixed due to a long period of non-use or to contamination, UNDER NO CIRCUMSTANCES must an attempt be made to free them by gripping the ram with any device. The simplest way to free them is to run hot water around the cell top, not on the ram, resulting in expansion of the cell top. The ram will then fall easily from the above. Then lightly coat the ram and bore with a light machine oil (clean) and gently re-enter the ram using a reciprocating and rotating motion.

If storage is to be necessary, ensure the ram and bush are cleaned, then coated in a light machine oil and stored in a clean cupboard or box where soil dust is absent. Preferably it should be covered with a polythene bag.

Refer to our catalogue for the part numbers of the internal accessories required for use with our triaxial cells and the choice of specimen sizes available.

Wykeham Farrance
international



- **Banded Cell**

  For extra protection when using compressed air systems
- **2000kPa and 3400kPa working pressure**

  3400kPa on 70mm cell
- **Separate cell chamber clamping**

  Prevents over stressing chamber. Ensures correct alignment

WFi 2000 & 3400 kPa Triaxial Cells

Designed to accommodate advanced electronic testing & monitoring devices.

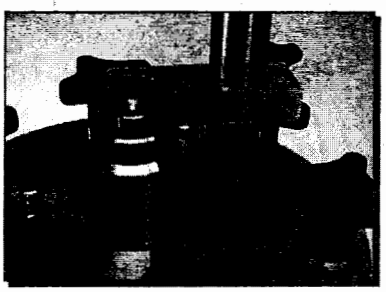
All cells are fitted as standard with 5 no volume change valves, built in ram clamp, dial gauge or transducer supports and large easy to use clamp control handles. In addition WFi provides a service to adapt cells to accommodate special testing requirements.

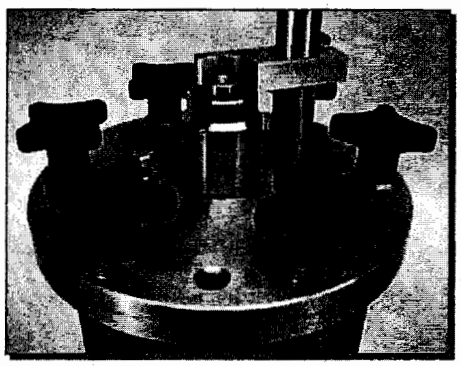
Four cell sizes

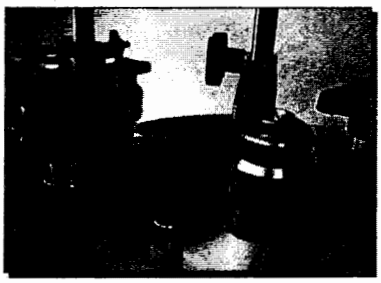
Cell Size	Sample Size	Part No.
50mm diameter	35mm - 50mm	10201
70mm diameter	38mm - 76mm	10751
100mm diameter	50mm - 105mm	11001
150mm diameter	100mm - 150mm	11144

Technical Specification

Triaxial Cells and Accessories							
Cell Part No	Sample Size	Pedestal	Top Cap	Base Disc	Porous Disc	Membrane	O Ring
10201	1.4 inch	10230	10310	10370	10550	10490	10520
	35mm	10231	10311	10371	10551	10490	10520
	38mm	10240	10320	10380	10560	10500	10530
	50mm	10251	10331	10391	10571	10510	10540
10751	2.8 inch	10776	10761	10771	10841	10821	10831
	70mm	10777	10762	10772	10842	10821	10831
11001	100mm	11033	11011	11021	11111	11091	11100
	105mm	11034	11012	11022	11112	11091	11100
11144	150mm	11166	11151	11161	11231	11221	11240







Sample Accessories						
Cell Part No	Sample Size	Suction Device	O Ring Placing Tool	Three Part Split Former	Two Part Split Mould	Filter Drains
10201	1.4 inch	10460	10542	10400	10430	10669
	35mm	10460	10542	10401	10431	10669
	38mm	10460	10542	10410	10440	10670
	50mm	10480	10544	10421	10451	10671
10751	2.8 inch	10810	10545	10801	10792	10866
	70mm	10810	10545	10802	10793	10866
11001	100mm	11080	10546	11052	11053	11044
	105mm	11081	10547	-	11054	11044
11144	150mm	11210	10548	11191	-	11242

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Wykeham Farrance International
Weston Road
Slough
England
SL1 4HW

Tel: +44 1753 571241
Fax: +44 1753 811313
Email: sales@wfi.co.uk

Triaxial cells

WF Triaxial cells for specimens up to 150 mm dia.

All cells are fitted as standard with 5 no volume change valves, built-in ram clamp, dial gauge or transducer supports and large easy to use clamp control handles. The length of the chamber is suitable for submersible load cells.
In addition WF provides a service to adapt cells to accommodate special testing requirements.

Triaxial cells

Code	WF 10201	WF 10751	WF 11001	WF 11144
Nominal size (Ø mm)	38	70	100	150
Max. specimen size (Ø mm)	35-50	38-71	50-105	100-150
Max. working pressure (kPa)	2000	3400	2000	2000
Max. height (mm)	410	500	564	650
Diameter (mm)*	350	400	440	500
Weight (kg)	7	15	21	40

* Including valves

General specifications

- Light alloy construction, stainless steel ram and O ring seal
- Built-in cell ram clamp
- Includes pillar and anvil for strain dial gauge or transducer
- Five on/off no-volume change valves fitted as standard
- Sample sizes between 35 mm and 150 mm dia.
- Standard length chamber accepts submersible load cells
- Rapid assembly design
- Cells are designed to accommodate a specimen with a length twice its diameter

Conversion sets

The sets listed are used to test smaller sample sizes in the 70 mm, 100 mm and 150 mm triaxial cells. Each set consists of a pedestal, top cap and drainage lead.

WF 11121
Conversion set for testing 38 mm samples in WF 10751 70 mm triaxial cell

WF 11122
Conversion set for testing 1.4 in. samples in WF 10751 70 mm triaxial cell

WF 11125
Conversion set for testing 50 mm samples in WF 10751 70 mm triaxial cell

WF 11136
Conversion set for testing 50 mm samples in WF 11001 100 mm triaxial cell

WF 11138
Conversion set for testing 2.8 in. samples in WF 11001 100 mm triaxial cell

WF 11139
Conversion set for testing 70 mm samples in WF 11001 100 mm triaxial cell

WF 11140
Conversion set for testing 100 mm samples in WF 11144 150 mm triaxial cell

Important note. *The Advanced Triaxial Cells with wire outlets for transducers are shown on page 42.*

Main features

- ***Banded cell*** *For extra protection when using compressed air systems*
- ***2000 kPa and 3400 kPa working pressure*** *3400 kPa on 70 mm cell*

- ***Separate cell chamber clamping*** *Prevents over stressing chamber. Ensures correct alignment.*

WF 10201 *WF 10751* *WF 11001*

Triaxial cells accessories (Part No.)

Cell type	Sample size	Pedestal	Top cap(1)	Base disc	Pair of porous disc	Membrane(2)	O ring(2)
WF 10201	1.4 in.	*WF 10230*	*WF 10310*	*WF 10370*	*WF 10550*	*WF 10490*	*WF 10520*
	35 mm	*WF 10231*	*WF 10311*	*WF 10371*	*WF 10551*	*WF 10490*	*WF 10520*
	38 mm	*WF 10240*	*WF 10320*	*WF 10380*	*WF 10560*	*WF 10500*	*WF 10530*
	50 mm	*WF 10251*	*WF 10331*	*WF 10391*	*WF 10571*	*WF 10510*	*WF 10540*
WF 10751	2.8 in.	*WF 10776*	*WF 10761*	*WF 10771*	*WF 10841*	*WF 10821*	*WF 10831*
	70 mm	*WF 10777*	*WF 10762*	*WF 10772*	*WF 10842*	*WF 10821*	*WF 10831*
WF 11001	100 mm	*WF 11033*	*WF 11011*	*WF 11021*	*WF 11111*	*WF 11091*	*WF 11100*
	105 mm	*WF 11034*	*WF 11012*	*WF 11022*	*WF 11112*	*WF 11091*	*WF 11100*
WF 11144	150 mm	*WF 11166*	*WF 11151*	*WF 11161*	*WF 11231*	*WF 11221*	*WF 11240*

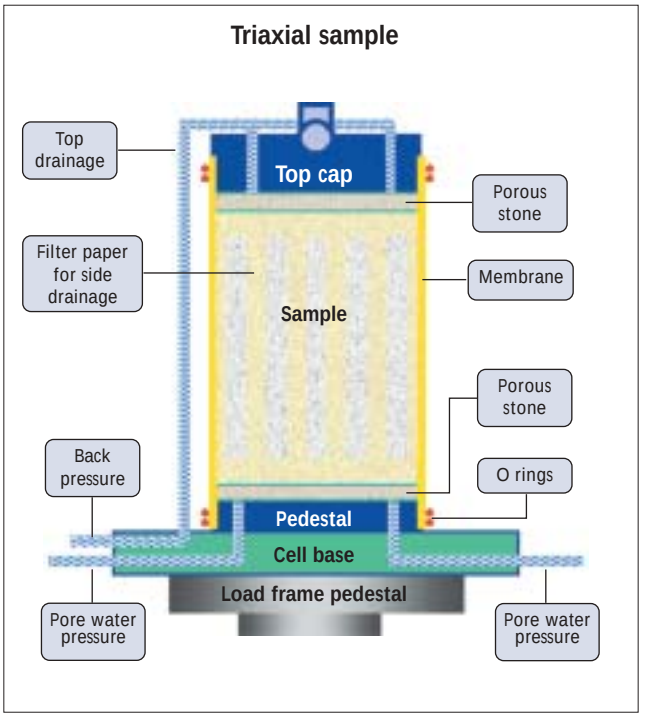
(1) Including drainage leads
(2) Pack of 10

Sample accessories (Part No.)

Cell type	Sample size	Suction device	O ring placing tool	Three part split former	Two part split mould	Filter drains	Hand samplers
WF 10201	1.4 in.	*WF 10460*	*WF 10542*	*WF 10400*	*WF 10430*	*WF 10669*	*WF 10627*
	35 mm	*WF 10460*	*WF 10542*	*WF 10401*	*WF 10431*	*WF 10669*	*WF 10622*
	38 mm	*WF 10460*	*WF 10542*	*WF 10410*	*WF 10440*	*WF 10670*	*WF 10623*
	50 mm	*WF 10480*	*WF 10544*	*WF 10421*	*WF 10451*	*WF 10671*	*WF 10624*
WF 10751	2.8 in.	*WF 10810*	*WF 10545*	*WF 10801*	*WF 10792*	*WF 10866*	*WF 10628*
	70 mm	*WF 10810*	*WF 10545*	*WF 10802*	*WF 10793*	*WF 10866*	*WF 10625*
WF 11001	100 mm	*WF 11080*	*WF 10546*	*WF 11052*	*WF 11053*	*WF 11044*	*WF 10626*
	105 mm	*WF 11081*	*WF 10547*	-	*WF 11054*	*WF 11044*	*WF 10629*
WF 11144	150 mm	*WF 11210*	*WF 10548*	*WF 11191*	-	*WF 11242*	-

Triaxial cell accessories

WF 10623



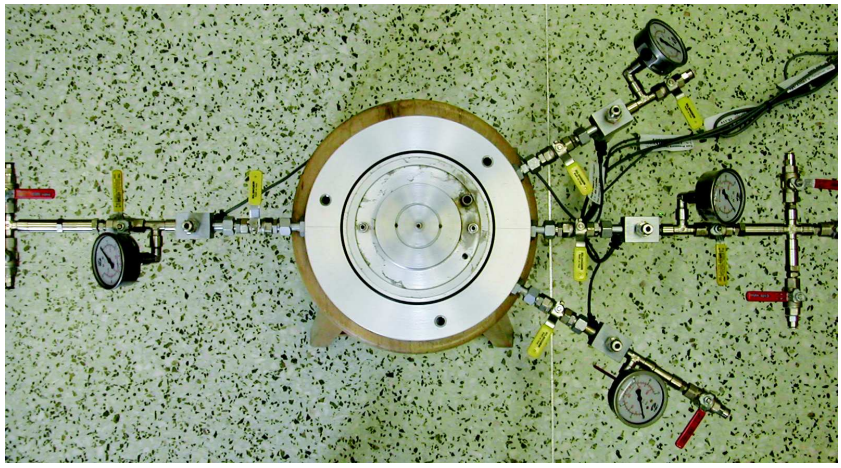


Figure 2.3: Wykeham Farrance base plate WF11001/SN:100257-9

2.1 The base plate of the WF triaxial cell

The base plate of the triaxial cell is a circular light alloy material of thickness $t_{base\,plate}$ and diameter $d_{base\,plate}$, on which the chamber is firmly screwed on. The watertightness of the base plate and the chamber is achieved via an O-ring, which is placed in a circular groove, on the base plate. Eight (8) on-off valves, four (4) de-airing blocks with analog and digital pressure transducers are installed in the four pressure lines coming out of the base plate. Two of them are used to fill the cell with water or silicon oil and thus measure the cell pressure during a triaxial test and the other two are installed in the pore pressure line. The main purpose of the on-off valves in these pressure lines is to be able to isolate, apply and measure the respective pressures (cell and pore). The installation of de-airing blocks between the on-off valves allows for the escape of trapped air inside the system of pipes-hoses.

The base plate has also detachable base platens (these are sometimes referred as pedestals or pressure pads). Different platen sizes are available, according to the diameter of the specimen. The pedestal is fitted using three hexagonal headed screws. On the upper side of the base plate there is a centering "pimple" or small projection. There is an equivalent hole on the underside of the base platen (the underside is the side with the O-ring seals). The pimple is located in the hole on the platen and the platen is then centered equally. The base of the cell is now turned over. The hexagonal screws are placed in the three holes until each is correctly seated. The screws are tightened equally until tight. Openings between the pedestal and the base plate allow for inter-connection.

Looking from the top of the base plate (see Figure2.4, the leftmost pressure line is used to fill the chamber with water. Along the line a RS Type

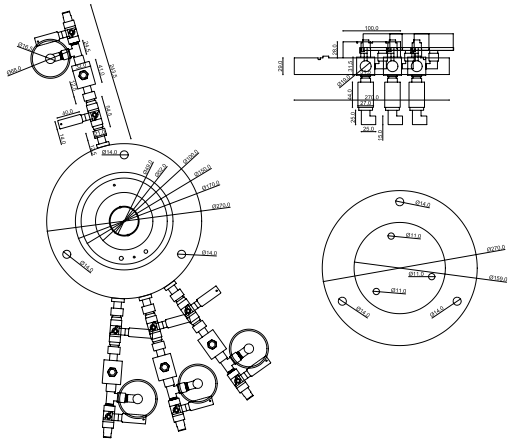


Figure 2.4: Top and side view of Wykeham Farrance base plate WF11001/SN:100257-9

249-S086219 pressure transducer is used for measuring the cell pressure. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the pressure transducer follows the below mentioned cabling: excitation voltage + (red), excitation voltage − (green), output voltage + (blue), output voltage − (yellow) and ground (shield). Table 2.1 summarises the main specifications and calibration constants of the cell pressure transducer, while Figure 2.6 and 2.7 show the calibration charts.

Moving right, the next pressure line is connected to the specimen at the pedestal, and is used either to flush water into the specimen, or allow drainage from the specimen. Along the line a 2200AGB1001A2UA003 pressure transducer is used for measuring the pore water pressure. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the pressure transducer follows the below mentioned cabling: excitation voltage + (red), excitation voltage − (yellow), output voltage + (black), output voltage − (white) and ground (shield). Table 2.2 summarises the main specifications and calibration constants of the pore pressure transducer, while Figure 2.9 and 2.10 show the calibration charts.

The third pressure line is connected to the air-water pressure cell, which is used to apply the cell pressure. At the same time it can be used to fill the cell with water. Along its line a 2200AGB1001A2UA003 pressure transducer is used for measuring the cell pressure. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the pressure transducer follows the below mentioned cabling: excitation voltage + (red), excitation voltage

Operator	GIO	GIO & NITHE
Place	GeoLab	GeoLab
Date	2004-07-04	2004-11-23
Time	15:30	13:55
Maximum pressure	10.0bar	10.0bar
Calibration constant	9.947kPa/mV	10.006kPa/mV
Linearity	99.999%	99.999%
Excitation voltage	10.11Volts	10.11Volts
Voltage Sensitivity	9.80mV/V	9.36mV/V
Sampling rate	1.000samples/sec	1.000samples/sec
Temperature	30.8^0	24.0^0
Humidity	34%	31%

Table 2.1: RS Type 249-S086219-Cell Pressure-Port1 Calibration Table

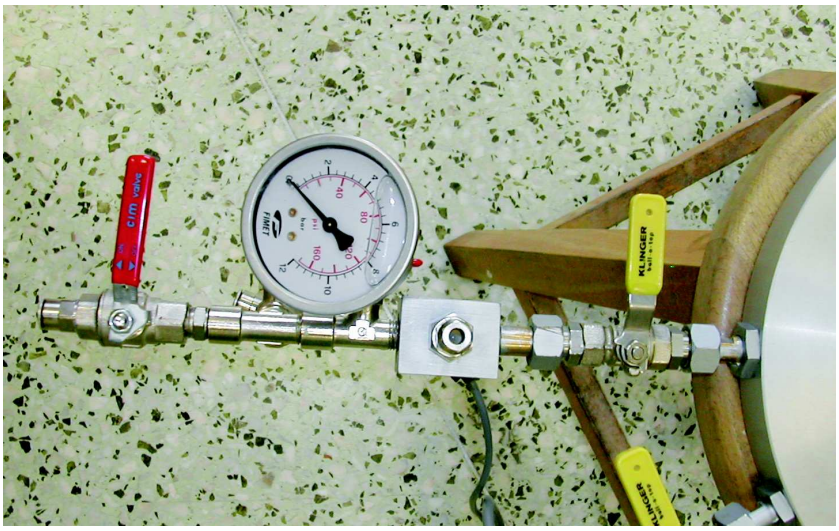


Figure 2.5: Cell pressure line (Port1)

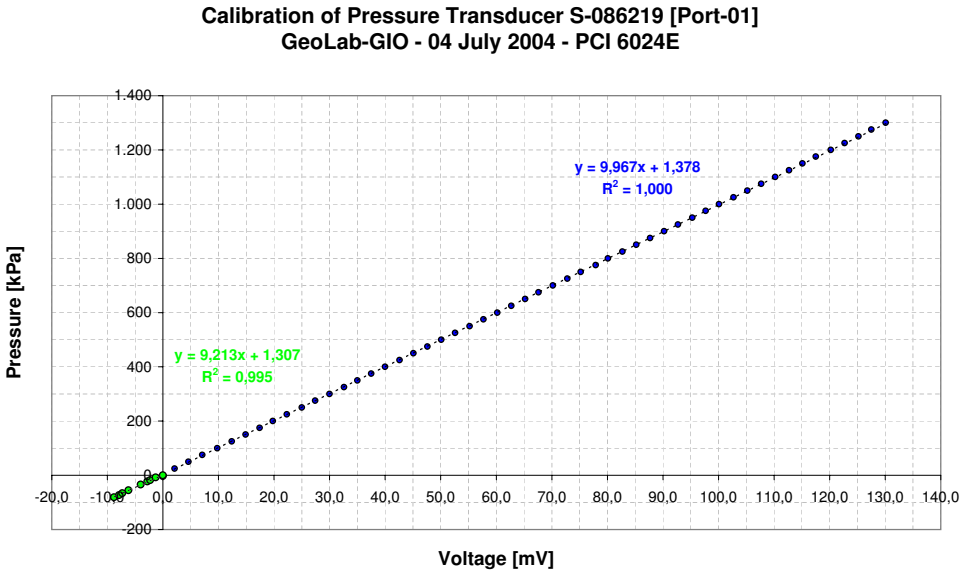


Figure 2.6: RS Type 249-S086219-Cell Pressure-Port1 Calibration, 2004-07-04

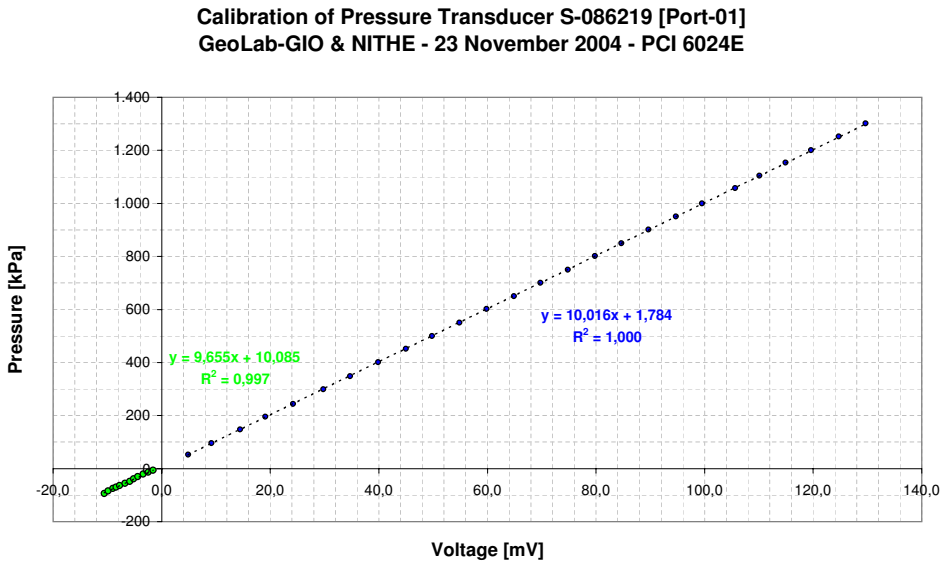


Figure 2.7: RS Type 249-S086219-Cell Pressure-Port1 Calibration, 2004-11-23

Operator	GIO	GIO & NITHE
Place	GeoLab	GeoLab
Date	2004-07-05	2004-11-23
Time	17:10	13:55
Maximum pressure	10.0bar	10.0bar
Calibration constant	9.989kPa/mV	9.876kPa/mV
Linearity	99.999%	99.999%
Excitation voltage	10.11Volts	10.11Volts
Voltage Sensitivity	9.83mV/V	9.48mV/V
Sampling rate	1.000samples/sec	1.000samples/sec
Temperature	30.0^0	24.0^0
Humidity	30%	31%

Table 2.2: 2200AGB1001A2UA003-Pore Pressure-Port2 Calibration Table

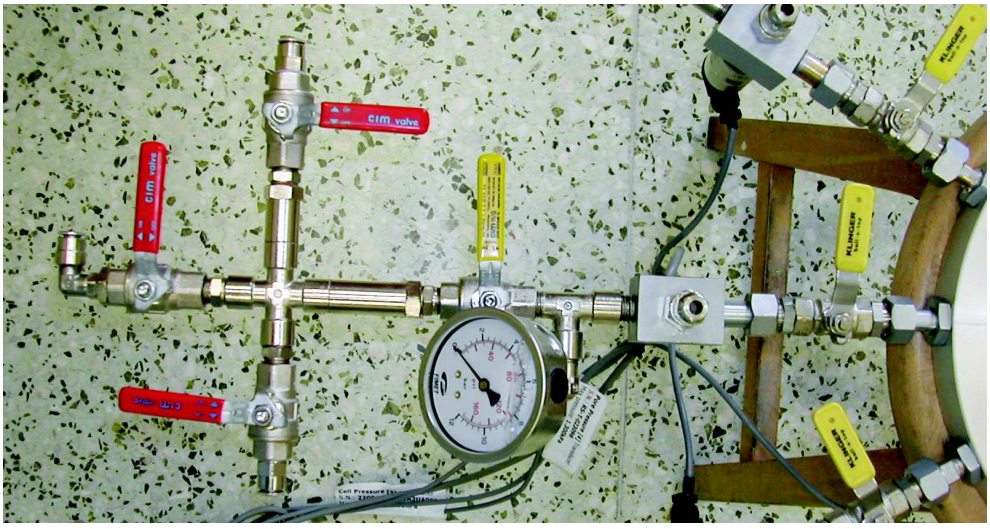


Figure 2.8: Pore pressure line (Port2)

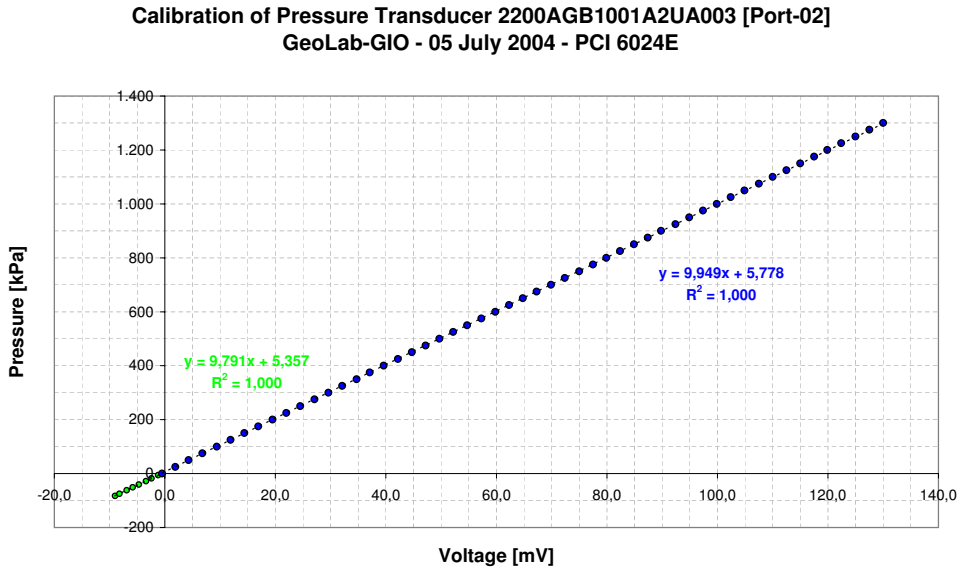


Figure 2.9: 2200AGB1001A2UA003-Pore Pressure-Port2 Calibration, 2004-07-05

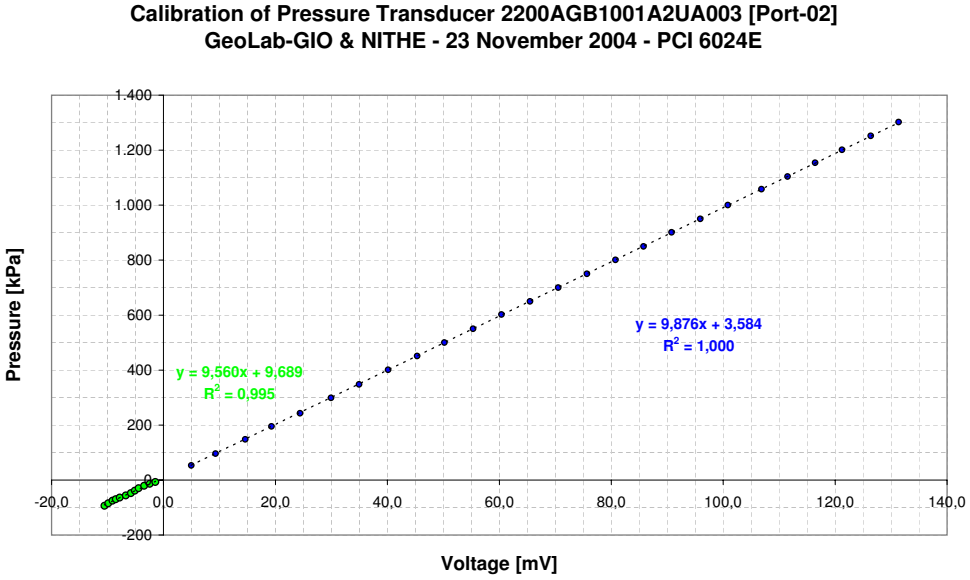


Figure 2.10: 2200AGB1001A2UA003-Pore Pressure-Port2 Calibration, 2004-11-23

Operator	GIO	GIO & NITHE
Place	GeoLab	GeoLab
Date	2004-07-05	2004-11-23
Time	18:05	13:55
Maximum pressure	10.0bar	10.0bar
Calibration constant	9.953kPa/mV	10.015kPa/mV
Linearity	99.9996%	99.999%
Excitation voltage	10.11Volts	10.11Volts
Voltage Sensitivity	9.90mV/V	9.36mV/V
Sampling rate	1.000samples/sec	1.000samples/sec
Temperature	30.1^0	24.0^0
Humidity	30%	31%

Table 2.3: 2200AGB1001A2UA003-Cell Pressure-Port3 Calibration Table

Operator	GIO	GIO & NITHE
Place	GeoLab	GeoLab
Date	2004-07-05	2004-11-23
Time	16:05	13:55
Maximum pressure	10.0bar	10.0bar
Calibration constant	9.946kPa/mV	10.003kPa/mV
Linearity	99.996%	99.999%
Excitation voltage	10.11Volts	10.11Volts
Voltage Sensitivity	9.89mV/V	9.35mV/V
Sampling rate	1.000samples/sec	1.000samples/sec
Temperature	30.0^0	31.0^0
Humidity	31%	24%

Table 2.4: RS Type 249-T023096-Pore Pressure-Port4 Calibration Table

− (green), output voltage + (blue), output voltage − (yellow) and ground (shield). Table 2.3 summarises the main specifications and calibration constants of the cell pressure transducer, while Figure 2.12 and 2.13 show the calibration charts.

Finally, the fourth pressure line installed at the base pedestal is connected to the top cap of the specimen. A RS Type 249-T023096 pressure transducer is installed and measures the pore water pressure. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the pressure transducer follows the below mentioned cabling: excitation voltage + (blue), excitation voltage − (green), output voltage + (red), output voltage − (yellow) and ground (shield). Table 2.4 summarises the main specifications and calibration constants of the cell pressure transducer, while Figure 2.15 and 2.16 show the calibration charts.

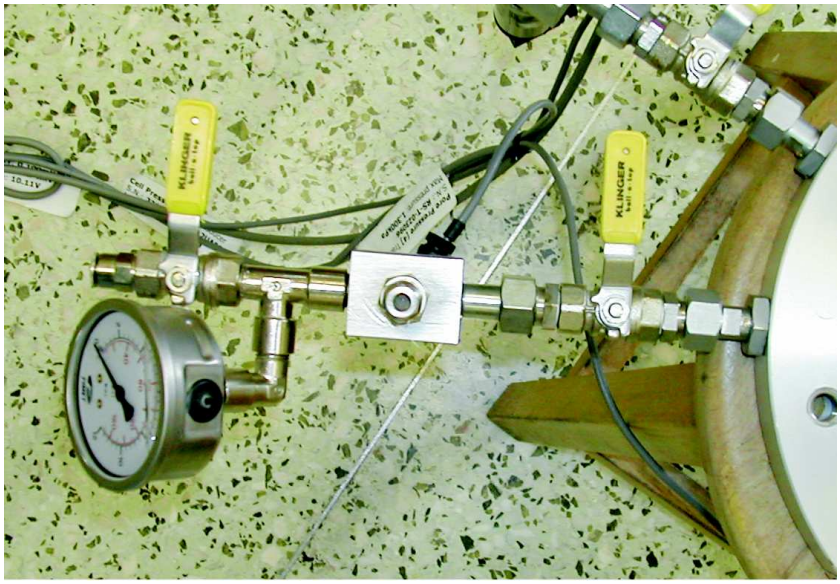


Figure 2.11: Cell pressure line (Port3)

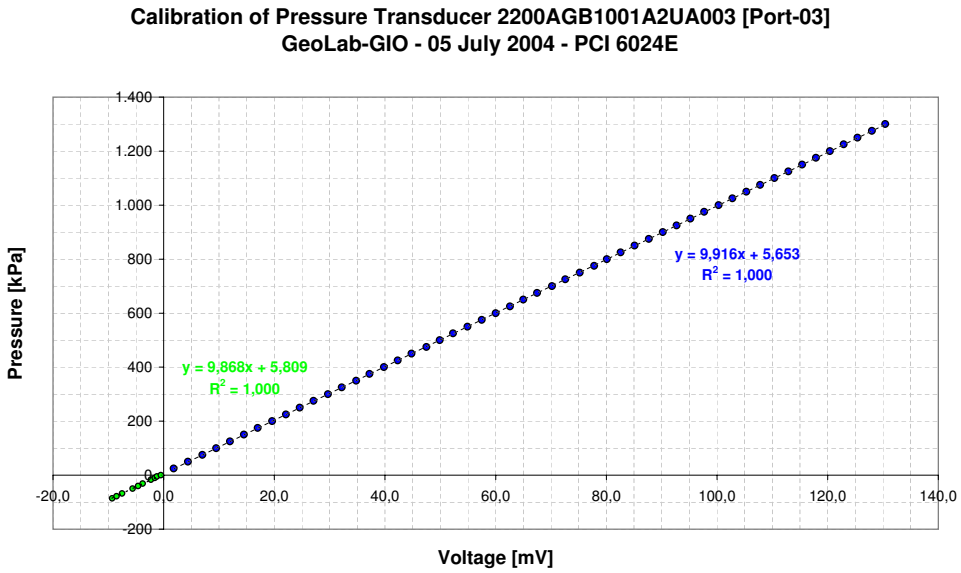


Figure 2.12: 2200AGB1001A2UA003-Cell Pressure-Port3 Calibration, 2004-07-05

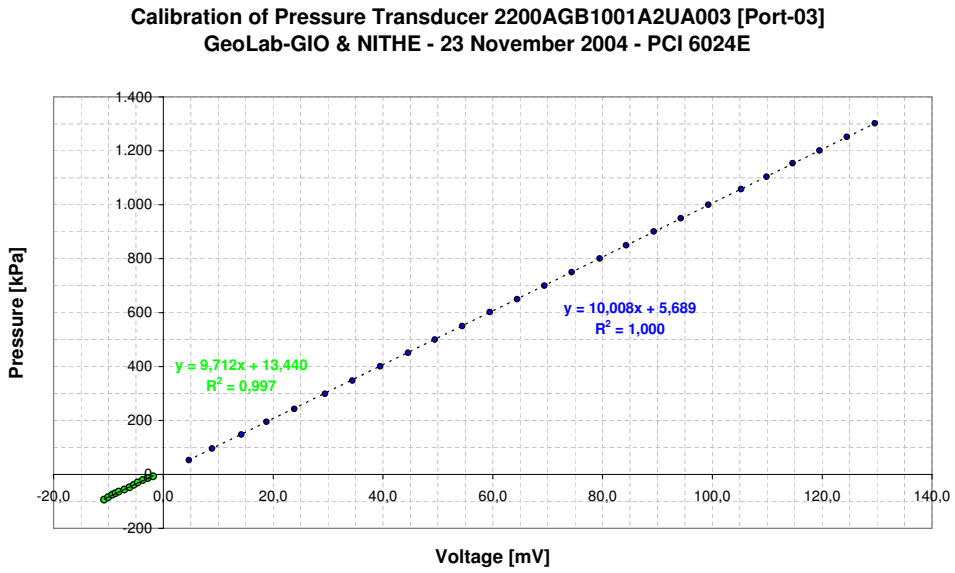


Figure 2.13: 2200AGB1001A2UA003-Cell Pressure-Port3 Calibration, 2004-11-23

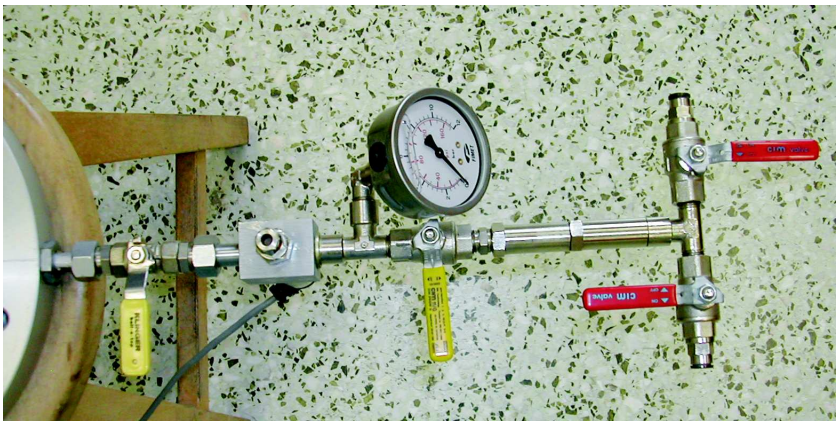


Figure 2.14: Pore pressure line (Port4)

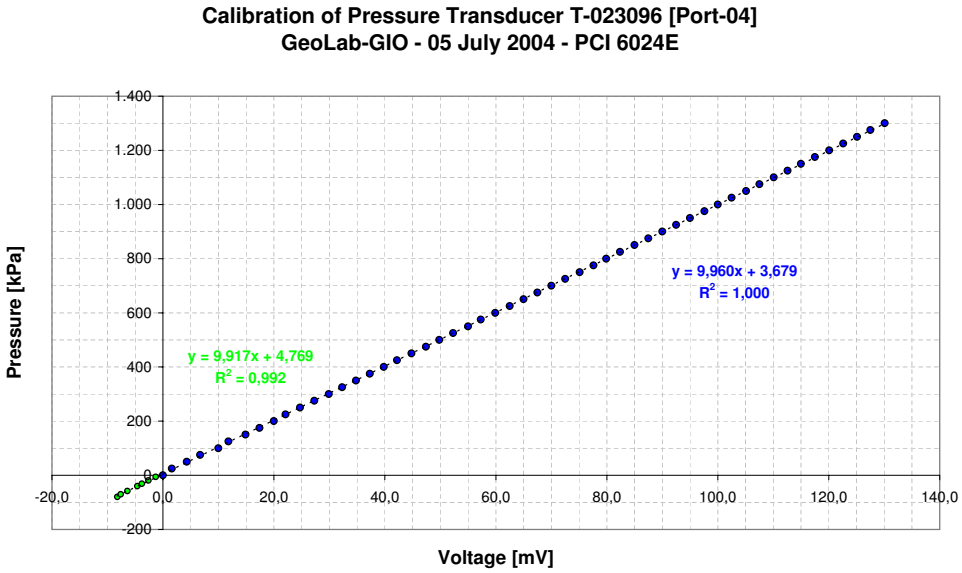


Figure 2.15: RS Type 249-T023096-Pore Pressure-Port4 Calibration, 2004-07-05

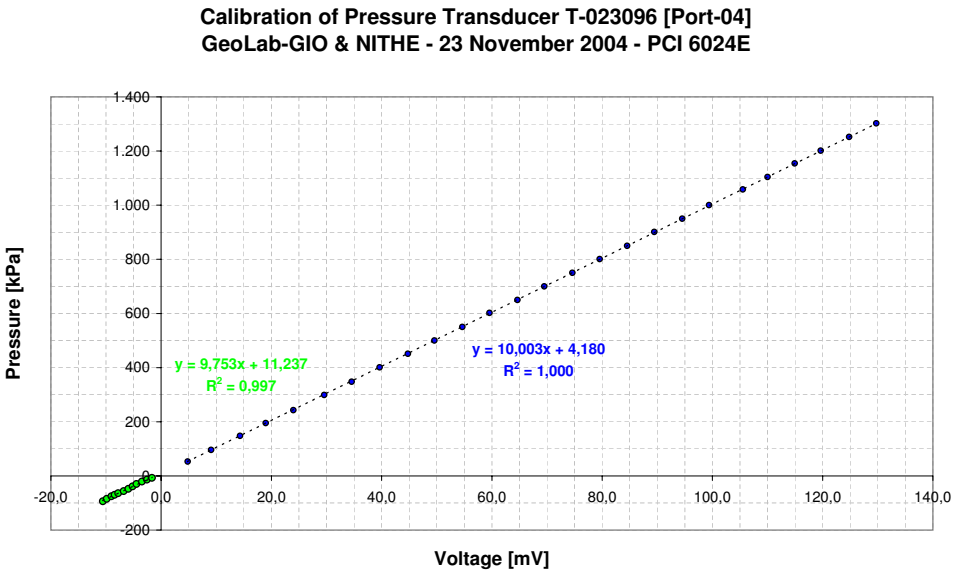
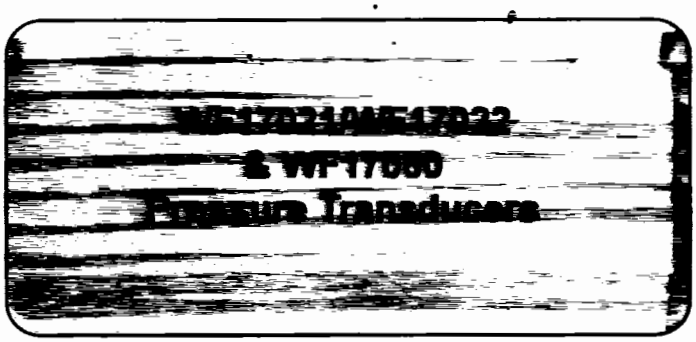


Figure 2.16: RS Type 249-T023096-Pore Pressure-Port4 Calibration, 2004-11-23



Serial No

WYKEHAM FARRANCE ENGINEERING LIMITED
Weston Road
Trading Estate
Slough
Berks, SL1 4HW
England

Telephone 01753 571241
Telefax 01753 811313
Telex 847301 WFENG G

Contents

INTRODUCTION 3
INSPECTION 3
SPECIFICATION 3
WF17029 DE-AIRING BLOCK 4
CONNECTION OF WF17029 AND PRESSURE TRANSDUCER 4
DE-AIRING THE WF17029 AND TRANSDUCER 4
CALIBRATION 4
MAINTENANCE 5

INTRODUCTION

This Appendix describes the use of the following Wykeham Farrance products:

	kPa	psi
WF17060	0 - 1000	0 - 145
WF17021	9 - 1700	0 - 250
WF17022	0 - 3300	0 - 480

It is written as an Appendix to the Wykeham Farrance CLISP software manual. However, it is a self contained document and is also used as a separate instruction and operating manual for these products.
This range of transducers have been specially designed or selected for use in soil mechanics laboratories for the measurement of cell pressure or pore pressure in triaxial or consolidation tests.

The WF17060 is the workhorse of the conventional soil mechanics laboratory. The advanced design and construction of this transducer ensures exceptional linearity and temperature stability. A silicon strain gauge bridge is diffused into a single crystal silicon diaphragm using micro-circuit, alloying and bonding techniques; electron beam weld. A robust steel/titanium body fitted and a special gel is used to protect the strain gauges from corrosive pore-water or condensation.

The other pressure transducers are produced to similar high standards but are intended to cover pressure ranges beyond those used in conventional test procedures.

INSPECTION

Your Transducer was thoroughly inspected before it was shipped and should be ready to operate as soon as you have completed the setup procedure. Notify Wykeham Farrance or your local agent and file a claim with any carriers involved if you find any damage to the machine.

SPECIFICATION

	WF17021	WF17022	WF17060
Pressure range	0 - 1700 kPa (0 - 250 p.s.i.)	3300 kPa (0 - 500 p.s.i.)	0 - 1000 kPa (0 - 145 p.s.i.)
Supply	10 v DC	10 v DC	[illegible]
Output	100 mV +/- 1.5 mV	100 mV +/- 1.5 mV	[illegible]
Non-linearity and hysteresis	+/- 0.02% FRO	+/- 0.02% FRO	Max +/- 0.2% BSL
Temperature Compensation range	-18 to + 66 C	-18 to + 66 C	+ 10 C to 40 C
Thermal zero shift	+/- 0.02% RDG/Deg C	+/- 0.02% RDG/Deg C	NA
Thermal sensitivity shift	+/- 0.02% RDG/Deg C	+/- 0.02% RDG/Deg C	NA
Temperature error band	NA	NA	Max +/- 0.5%
Thread size	1/4 BSP	1/4 BSP	[illegible]

For plug connections refer to calibration certificate.

WF17029 DE-AIRING BLOCK

A de-airing block is required to connect the pressure transducer to the triaxial cell or hydraulic/CRSC oedometers. (Note: WF17029 is not required where the transducer is screwed directly into the apparatus).

CONNECTION OF WF17029 AND PRESSURE TRANSDUCER

The pressure transducer must be carefully screwed into the de-airing block (make sure that the sealing washer is in place). The transducer should be gently tightened into place using a spanner on the spanner flats provided. [redacted].

Connection should now be screwed onto either the pore-pressure valve or the cell pressure valve, depending on which pressure is to be measured. In the case of hydraulic oedometer or C.R.S.C. oedometers the WF17029 and transducer should be connected to the appropriate valves on the apparatus. The pressure transducer should be positioned so that it points down.

Either the appropriate pressure line or a de-airing line should be connected to the valve of the de-airing block.

DE-AIRING THE WF17029 AND TRANSDUCER

The valve on the triaxial cell or oedometer apparatus should be closed. De-aired water should be connected to the valve.

Carefully remove bleed nut and open valve to allow water to displace the air. When all the air has been removed replace bleed nut. The valve of the de-airing block must open when bleed nut is tightened.
Now open the valve on the triaxial cell base or oedometer apparatus and allow de-aired water to flow through until all the air in WF17029 and cell base has been removed.

CALIBRATION

In order to use the electrical output of the pressure transducer. I[redacted]. The procedure for calibration will differ with the type of readout instrument used. The procedure for calibration should therefore be contained in the instruction manual for the readout device.

However the following general comments apply to all instruments:

1. The transducer should be connected to the read-out device and allow to '[redacted]' for 1 hour.
2. The transducer should be [redacted] before calibration is attempted. You do this by raising the pressure applied to the transducer fro[redacted].
3. After de-airing the system, close the cell valve and de-airing block valve and remove bleed nut. The trans ducer is now open to the atmosphere and under zero pressure.
4. Adjust the zero potentiometer to zero or press button on the read-out unit.
5. Open Valve on de-airing block and then replace bleed nut and gently tighten. Now apply the maximum pressure and adjust the gain to read the pressure applied or press button for maximum gain.
6. Now close valve on de-airing block and remove bleed Nut.

Now check zero and maximum pressure on display. If they do not agree then you should repeat the calibration again starting at step 4 until good agreement is reached at zero and maximum pressure.

Once this condition has been attained intermediate pressure values may be checked to establish the linearity of the trans-ducer.

MAINTENANCE

About once every six months a [redacted] should be placed into the WF17029 via bleed nut. The system should then be thoroughly flushed through with water until all the detergent and any accumulated dirt is removed. No other maintenance is necessary. The transducer does NOT CONTAIN ANY USER SERVICABLE COMPONENTS (other than the DIN plug).

PRESSURE TRANSDUCERS

2200 Series
General Purpose Industrial Pressure Transducers--Vacuum to 6000 psi (400 bar)

PDF Catalog Page
PDF Instruction Bulletins

- Millivolt, Voltage and Current Output Models
- Gauge, Absolute, Vacuum and Compound Pressure Models Available
- Submersible, General Purpose and Wash down Enclosures
- High Stability Achieved by CVD Sensing Element

The 2200 series features stability and accuracy in a variety of enclosure options. The 2200 series feature proven CVD sensing technology, an ASIC (amplified units), and modular packaging to provide a sensor line that can easily accommodate specials while not sacrificing high performance.

Typical Applications:

- Off Highway Vehicles
- Natural Gas Equipment
- Semiconductor Processing
- Power Plants
- Refrigeration
- Robotics
- HVAC

Specifications:

Input	
- Pressure Range	Vacuum to 400 bar (6000 psi)
- Proof Pressure	2 x Full Scale (FS) (1.5 x Fs for 400 bar, >= 5000
- Burst Pressure	>35 x FS <= 6 bar (100 psi); >20 x FS >=60 bar (1
- Fatigue Life	Designed for more than 100 million FS cycles
Performance	
- Long Term Drift	0.2% FS/year (non-cumulative)
- Accuracy	0.25 % FS typical (optional 0.15% FS)
- Thermal Error	1.5% FS typical (optional 1% FS)
- Compensated Temperatures	-20° C to 80° C (-5° F to 180° F)
- Operating Temperatures	-40° C to 125° C (-22° F to 260° F) for elec. codes A, B,
- Zero Tolerance	1% of span
- Span Tolerance	1% of span
- Response Time	0.5 ms
Mechanical Configuration	
- Pressure Port	See ordering chart
- Wetted Parts	17-4 PH Stainless Steel
- Electrical Connection	See ordering chart

- Enclosure	316 ss, 17-4 PH ss IP65 for elec. codes A, B, C,
- Vibration	70g, peak to peak sinusoidal, 5 to 2000 Hz (Rando
- Acceleration	100g steady acceleration in any direction 0.032% F
- Shock	20g, 11 ms, per MIL-STD.-810E Method 516.4 Proced
- Approvals	CE, UR (22ET, 26ET Intrinsically safe)
- Weight	Approx. 100 grams (additional cable; 75 g/m)
Millivolt Output units	
- Output	100 mV (10 mv/v)
- Supply Voltage (Vs)	10 Vdc (15 Vdc max.) Regulated
- Bridge resistance	2600-6000 ohms
Voltage Output units	
- Output	see ordering chart
- Supply Voltage (Vs)	1.5 Vdc above span to 35 Vdc @ 6 mA
- Supply Voltage Sensitivity	0.01% FS/Volt
- Min. Load Resistance Current Consumption	(FS output / 2) Kohms approx 6 mA at 7.5V output
Current Output units	
- Output	4-20 mA (2 wire)
- Supply Voltage (Vs)	24 Vdc, (7-35 Vdc)
- Supply Voltage Sensitivity	0.01% FS/Volt
- Max. Loop Resistance	(Vs-7) x 50 ohms

How To Order:
To order this product, simply select from the drop boxes below to construct your product code. The pricing and lead time will displayed on a new page; enter the quantity you need and the item will be added to your shopping cart.

1† - Basic Type	2200 - CVD Pressure Transducer**
2† - Output	
3† - Pressure Datum	
4† - Pressure Range	
5† - Pressure Port	
6† - Electrical Connection	
7† - Apparatus Protection	
8† - Cable Length	
9† - Performance (Accuracy/Thermal)	

** Stock Option - Part numbers built using all stock options can be shipped next day.

† Selection Required

* View the dimension chart for help in ordering.

Create Part Number

* View the dimension chart for help in ordering.

Gems Sensors

OPERATING & INSTALLATION INSTRUCTIONS

RS TYPE 249 GAUGE SENSORS

PLEASE READ CAREFULLY BEFORE INSTALLING

Part Number 560550-0066 **Issue B**

IMPORTANT NOTE: All GEMS Pressure and Level & Flow Products are designed and manufactured in accordance with Sound Engineering Practice as defined by the Pressure Equipment Directive 97/23/EC.
Pressure transducer products designed to meet the highest risk category"IV" of the Pressure Equipment Directive are clearly marked on the label by "CE0086". Compliance is achieved through modules "B+D".
No other products should be used as "Safety Accessories" as defined by the PED, Article 1. Paragraph 2.1.3.

INTRODUCTION

Series Type 249 Gauge Transducers and Transmitters with the CE Mark conform with the essential protection requirements of the EMC Directive 89/33/EEC amended by certified type testing to EN 50082-2 and EN 50081-1.

ELECTRICAL INSTALLATION

All types with the CE mark include suppression devices providing transient proteetion to EN 61000-4-2 and EN 61000-4-4. Conformity with the requirements of the CE mark only applies wheu eonnection is made with Gems Sensors approved cable, see Approved Cable section, and is connected as shown below:

Millivolt Output Transducers: Fuur core screened cable should be used with the cable screen connected to the instrumentation earth. The cable screen should not be connected to the transducer body.

4-20 mA Two-wire Transmitters: The screen of the cable must be earthed at the instrumentation end. If an "Earth Loop" problem is encountered when the body of the unit is earthed by the pipework it is permissable to remove the cable screen from the instrumentation earth.

mV	Connections	4-20mA	Connections
249-3864		249-3870	
249-3959	+ve Supply Pin	249-3943	
249-3858	1	249-3937	+vePin 1
249-3965	+ve Output Pin2	249-3921	-ve Pin 2
249-3836	-ve Output Pin 3	249-3915	Earth
249-3820	-ve Supply Earth	249-3892	
249-3971		249-3886	

WETTED PARTS

17-4 PH stainless steel plus nickel Braze to BS1845: NK3/HTN2

APPROVED CABLE

Gems Sensors uses cables comprising 2,3 or 4 colour-coded cores, enclosed by an alumnised polyester screen where the screen is in intimate contact with a separate drain wire. The outer sheath is chrome PVC and overall diameter is approximately 4mm

GENERAL

- Pressure range must be compatible with the maximum pressure being measured.
- Pressure media must be compatible with the transducer/transmitter wetted parts listed in these instructions
- Liquid must not be allowed to freeze in the pressure port
- The gasket must be fitted under the electrical connector.

MECHANICAL INSTALLATION

Mounting: Omni-directional, self supported directly into the pipework. Use a 19mm AF (3/4") spanner on the hexagon provided to apply a maximum torque of 15.8Nm.

OPERATION

Having installed the transducers as instructed, they are ready for use. Before applying power, check that the correct polarity and excitation levels are being applied.

LOAD CHARACTERISTICS (4-20mA Current Output)

The total resistive load in the loop (to include all the cable resistance) can be from 'zero to 50 x (supply volts - 7) ohms' e.g. with a 24V d.c. supply the permissible load is from zero up to 850 ohms.

WARRANTY

We guarantee this instrument against faulty workmanship and material for a period of one year from date of delivery. The Company undertake to repair, free of charge, ex-works any instrument found to be defective within the specified period providing the instrument has been used within the specification in accordance with these instructions and has not been misused in any way.

Detailed notice of such defects and satisfactory proof thereof must be given to the Company immediately after the discovery and the goods are to be returned free of charge to the Company, carefully packed and accompanied by a detailed failure report.

MAINTENANCE

Routine Inspection: Not required except for periodic inspection of the cable and connector to ensure that these are neither damaged nor softened by incompatible liquid.

TransInstruments

OPERATING & INSTALLATION INSTRUCTIONS

SERIES 2000

PLEASE READ CAREFULLY BEFORE INSTALLING

PART NUMBER: 558140-0032 **ISSUE E**

INTRODUCTION

The Series 2000 pressure transducers use molecularly bonded high output strain gauges to provide 100mV output for full range pressure, when used with a 10V d.c. power supply.

Series 2000 high output pressure transducers and transmitters are fitted with a hybrid amplifier providing various optional (at time of order) voltage outputs, and a 4-20mA current output capable of being used in control and indicating loops without further amplification.

CONTENTS

	PAGE
CALIBRATION	2
GENERAL	1
GROUNDING	2
LOAD CHARACTERISTICS	2
MAINTENANCE	4
MECHANICAL INSTALLATION	2
OPERATION	2
RETURN TO FACTORY	4
SERVICING	4
TABLE 1	3
WARRANTY	4
WETTED PARTS	4

GENERAL

- Pressure range must be compatible with the maximum pressure being measured.
- Pressure media must be compatible with the transducer/transmitter wetted parts listed in these instructions.
- Liquid must not be allowed to freeze in the pressure port.
- The gasket must be fitted under the electrical connector.

MECHANICAL INSTALLATION

Pressure Connections: G¼ external to BS.2779 compatible with ISO 228 (recommended seal Part Number 232646-0002 or Dowty Part Number 400-021-4490-41)

Mounting: Omni-directional self supported directly into the pipework. Use a 19mm AF (3/4") spanner on the hexagon provided to apply a maximum torque of 15.8 Nm.

OPERATION

Having installed the transducers as instructed, they are ready for use. Before applying power, check that the correct polarity and excitation levels are being applied. See Table 1 for electrical connections. Mating connector miniature DIN type Part Number 557230.

GROUNDING

All versions should be grounded by the installation pipework. If this is not possible then the high output transducers and transmitters should be grounded by an earth wire connected to the appropriate pin. Four core screened cable should be used with the millivolt version with the screen earthed at the instrumentation end.

CALIBRATION

Transducers are calibrated to the datum requested at time of order; this can be identified by the sixth letter of the identification code as follows:-

A - Absolute datum

G - Gauge datum vented to atmosphere via the electrical connector.

CHARACTERISTICS

The total permissible resistive load in the loop (to include all the cable resistance) can be from 'zero to 50 x (supply volts -12) ohms' e.g. with a 24 V d.c. supply the permissible load is from zero up to 600 ohms.

FIGURE 1

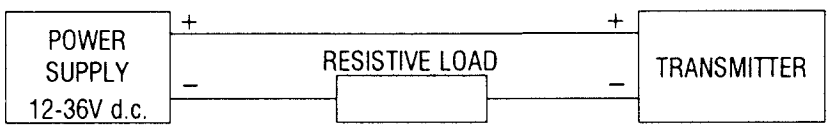
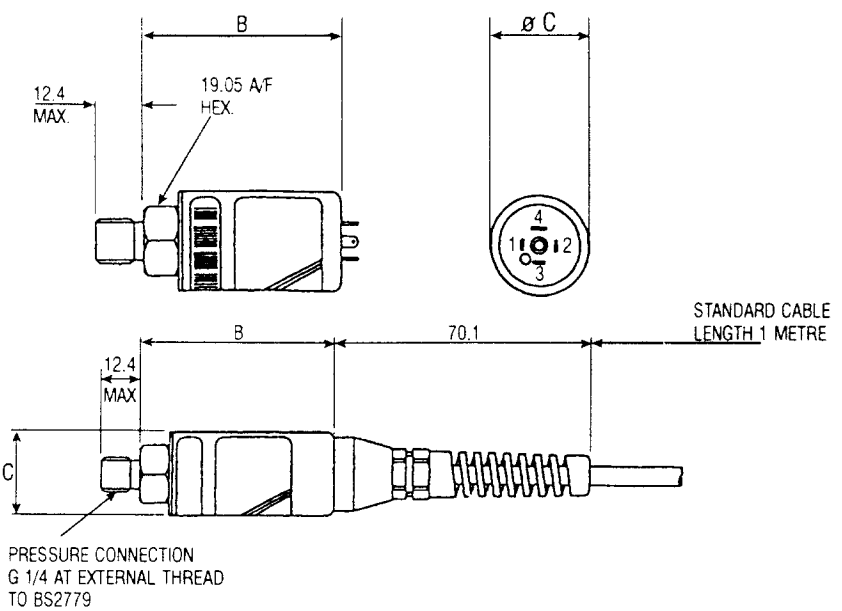


TABLE 1

ELECTRICAL CONNECTOR	OUTPUT					
	Millivolt		Voltage		Milliamp	
4 POLE MINIATURE						
Pin 1	Supply +ve		Supply +ve		+ve	
Pin 2	Output +ve		Common -ve		-ve	
Pin 3	Output -ve		Output +ve			
Pin 4	Supply -ve		Case Earth		Case Earth	
CABLE						
Red	Supply +ve		Supply +ve		+ve	
White			Output			
Blue	Output -ve					
Yellow	Output +ve					
Black			Common		-ve	
Green	Supply -ve					
ELECTRICAL			5V Span	10V Span	4-20 mA	
Rated	10V d.c.		24V d.c.	24V d.c.	24V d.c.	
Min/Max	5 - 15		7.5 - 30	12.5 - 30	12 - 36	
DIMENSIONS (mm)	B	C	B	C	B	C
	55	27.3	63.6	27.3	63.6	27.3



WARRANTY

We guarantee this instrument against faulty workmanship and materials for a period of one year from date of delivery. The Company undertake to repair, free of charge, ex-works any instrument found to be defective within the specified period providing the instrument has been used within the specification in accordance with these instructions and has not been misused in any way.

Detailed notice of such defects and satisfactory proof thereof must be given to the Company immediately after the discovery and the goods are to be returned free of charge to the Company, carefully packed and accompanied by a detailed failure report. See "RETURN TO FACTORY".

WETTED PARTS

17-4 PH stainless steel plus Nickle Braze to BS1845 : NK3/HTN2.

SERVICING

The instruments cannot be repaired locally and if damaged should be returned to ourselves at the address shown or to accredited dealers when a replacement/repair is required:

TRANSINSTRUMENTS
LENNOX ROAD
BASINGSTOKE
HANTS
RG22 4AW

RETURN TO FACTORY

PLEASE NOTE: To comply with Health and Safety requirements, the instrument must be clean and safe to handle and accompanied by a formal statement to that effect duly signed by an authorised officer of the Company.

Any instrument returned without certification will be quarantined and no action will occur until cleared. It may ultimately be returned to you and subject to a transportation charge.

MAINTENANCE

Routine Inspection: Not required except for periodic inspection of the cable and connector to ensure that these are neither damaged nor softened by incompatible liquid.

Handbook for use with WF17029 Transducer Block

Serial No

WYKEHAM FARRANCE ENGINEERING LIMITED
Weston Road
Trading Estate
Slough
Berks, SL1 4HW
England

Telephone 0753 571241
Telefax 0753 811313
Telex 847301 WFENG G

Instructions for the Use of Transducer Block WF 17029

The [redacted], shown in Fig. 1., is used for [redacted] in triaxial testing.

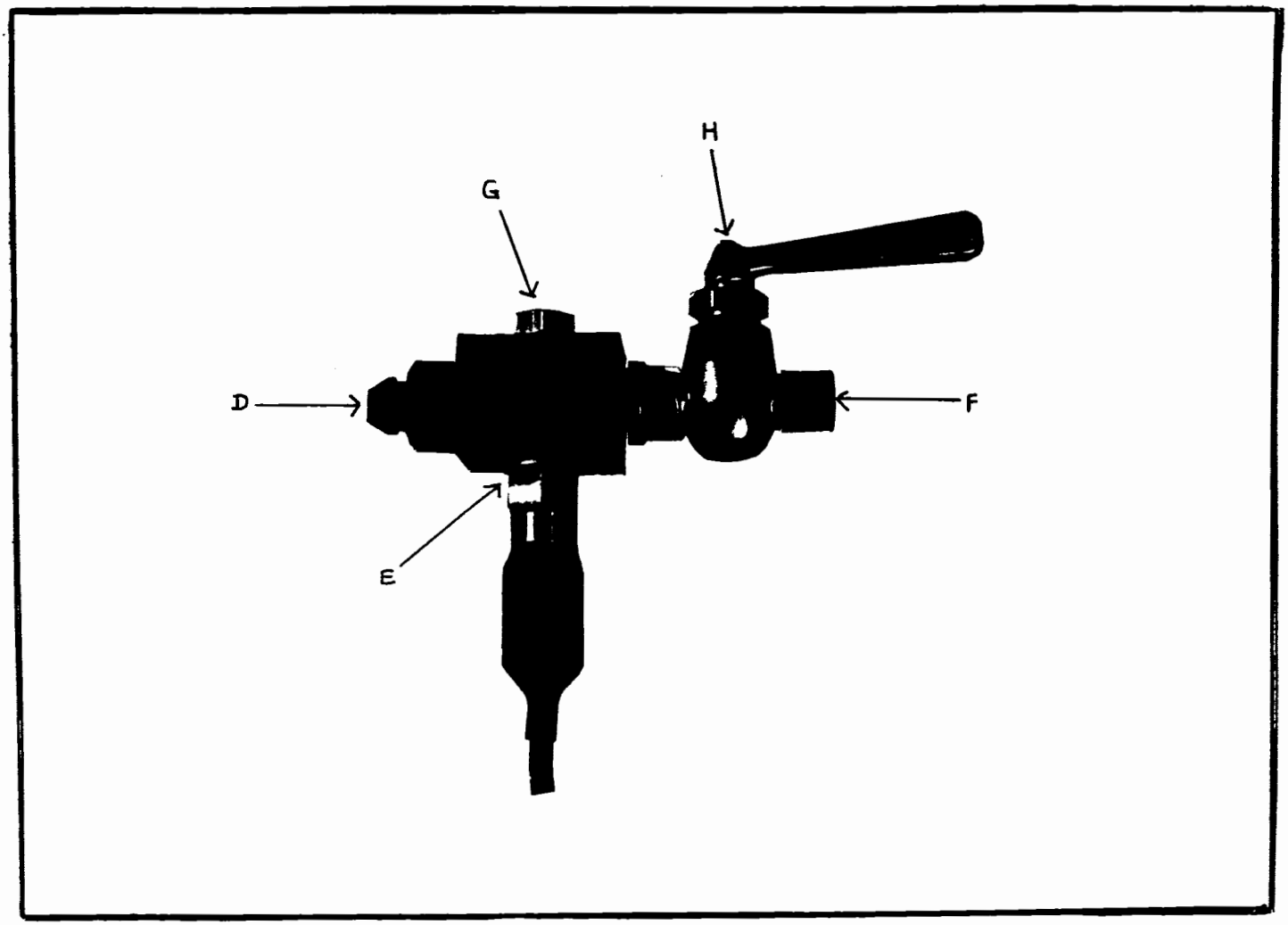


Fig. 1

To assemble the system:

1) Connect the transducer block at D to the pore pressure valve, B1, on the triaxial cell (Fig. 2)

2) Screw the pressure transducer, with its sealing washer, in to the bottom of the de-airing block at E, as shown in Fig. 1.

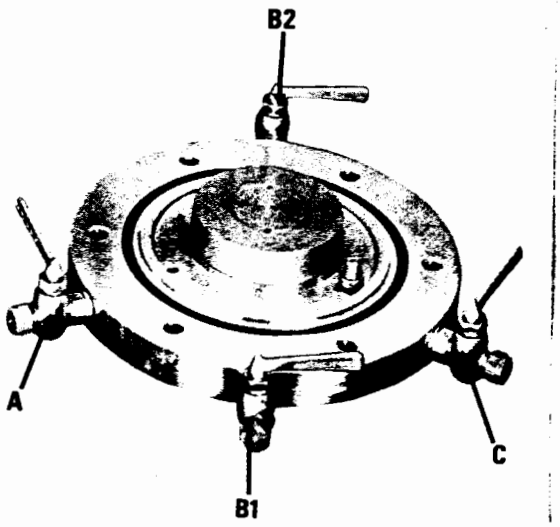


Fig. 2

NEOTEK

Συστήματα Δοκιμών & Μετρήσεων
Measuring & Testing Systems

EQA ISO 9001:2000 UKAS QUALITY MANAGEMENT 047

ΕΝΤΥΠΟ ΠΑΡΑΛΑΒΗΣ ΠΑΡΑΓΓΕΛΙΑΣ ΑΠΟ ΠΕΛΑΤΗ

Αρ. Παρ/λίας 24019

Βάσει του Προτύπου Ποιότητας ISO 9001:2000 που τηρεί η εταιρία μας, είναι αναγκαία η συμπλήρωση του παρακάτω εντύπου από τον πελάτη κατά την παραλαβή του υλικού.
Το έντυπο υπογράφεται και επιστρέφεται στην Εταιρία μας με φάξ στο 210-9359778 εντός 15 ημερών από την παραλαβή των ειδών ώστε να ισχύσουν και οι όροι εγγύησης του υλικού.

ΠΟΣΟΤΙΚΟΣ ΕΛΕΓΧΟΣ ΕΞΟΠΛΙΣΜΟΥ (Επισυνάπτεται πίνακας, αν δεν καλύπτεται από το παρόν):

	Τεμ		ΠΕΡΙΓΡΑΦΗ	Ποσότητα	Αριθ. Σειράς
1.	3	17029	De-Airing block for pressure transducers complete with on-off valve	3	17029
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10					

W.F. 17029
QTY. 3
W/O 58403.
ITEM 1

ΕΛΕΓΧΟΣ ΠΑΡΑΛΑΒΗΣ:

Συμφωνεί η παραγγελία με Δ. Αποστ/Τιμολόγιο/Σύμβαση κλπ ;	ΝΑΙ ☒	ΟΧΙ ☐
Συνοδεύουν πιστοποιητικά την παραγγελία (αν προβλέπονται) ;	ΝΑΙ ☒	ΟΧΙ ☐
Εντοπίστηκε φθαρμένη συσκευασία/παλέτες ;	ΝΑΙ ☐	ΟΧΙ ☒

Το εμπόρευμα είναι αποδεκτό και παραλαμβάνεται χωρίς επιφυλάξεις, ποσοτικές ή ποιοτικές. Τυχόν επιφυλάξεις πρέπει να αναφέρονται ρητά. ΝΑΙ ☒ ΟΧΙ ☐

ΠΑΡΑΤΗΡΗΣΕΙΣ - ΕΠΙΦΥΛΑΞΕΙΣ:

Ημερομηνία παραλαβής	Υπεύθυνος παραλαβής	Υπογραφή
13/04/04		

NEOTEK

Συστήματα Δοκιμών & Μετρήσεων
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ΓΕΩΡΓΟΠΟΥΛΟΣ ΙΩΑΝ-ΟΡΕΣΤ.

Ε. Μ. ΠΟΛΥΤΕΧΝΕΙΟ
ΣΕΜΦΕ
ΤΟΜΕΑΣ ΜΗΧΑΝΙΚΗΣ

ΗΡ. ΠΟΛΥΤΕΧΝΕΙΟΥ 5,
ΖΩΓΡΑΦΟΥ-ΑΘΗΝΑ 157 73

ΤΗΛ 210 7721373

FAX 210 7721302

ΕΠΙΒΕΒΑΙΩΣΗ ΠΑΡΑΓΓΕΛΙΑΣ

Στοιχεια μας:

09 Φεβρ 2004

Προμηθευτης:
WYKEHAM FARRANCE ENG., LTD. - UK

ΣΧΕΤΙΚΑ: Προσφορα μας No. 4-9028-3241

Σας ευχαριστουμε για την παραγγελια σας την οποιαν και επιβεβαιωνουμε ως ακολουθως:

αα	ΠΟΣ		ΠΕΡΙΓΡΑΦΗ	ΜΟΝΑΔΑ	ΣΥΝΟΛΟ
1.	3	17029	De-Airing block for pressure transducers complete with on-off valve	113.63	340.89
2.				0.00	0.00
3.				0.00	0.00
4.				0.00	0.00
5.				0.00	0.00
6.				0.00	0.00
7.				0.00	0.00
8.				0.00	0.00
9.				0.00	0.00
10.				0.00	0.00

Χρονος Παραδοσης: 20-30 ημερες απο ληψεως της παραγγελιας, εκτος απο περιπτωσεις ανωτερας βιας

Προελευση: ΑΓΓΛΙΑ

Εγκατασταση: Η παραδοση σε λειτουργια θα' γινει ΔΩΡΕΑΝ απο την εταιρια μας.

Κρατησεις: Κρατήσεις δεν περιλαμβάνονται και καμία κράτηση δεν θα γίνει αποδεκτή αν δεν ενημερωθούμε.

ΣΥΝΟΛΟ		340.89
	0.00	0.00
ΣΥΝΟΛΟ		340.89
ΦΠΑ 18%		61.36
ΣΥΝΟΛΟ	ΕΥΡΩ	402.25

Τοπος Παραδοσης:
ΑΘΗΝΑ

Πληρωμή: τοις μετρητοίς εντός 30 ημερών από την παράδοση

Τα ειδη θα πρεπει να αποθηκευθουν ασφαλως μεχρι την παραλαβη των και να παραληφθουν εντος 10 ημερων.

Η παραγγελία οριστικοποιείται μόνο μετά την επιστροφή του παρόντος υπογεγραμμένου.

Ε. Μ. ΠΟΛΥΤΕΧΝΕΙΟ
ΣΕΜΦΕ
ΤΟΜΕΑΣ ΜΗΧΑΝΙΚΗΣ

ΓΕΩΡΓΟΠΟΥΛΟΣ ΙΩΑΝ-ΟΡΕΣΤ.

ΝΕΟΤΕΚ ΟΕ - Π. ΞΥΣΤΡΗΣ & Σια
Ελ. Βενιζέλου 105, Ν. Σμυρνη
ΑΘΗΝΑ 171 23
Τηλ: 210-9341533 & 9359142
Fax: 210-9359778

Παν. Νικολακόπουλος

E10.03,1

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ΓΕΩΡΓΟΠΟΥΛΟΣ ΙΩΑΝ-ΟΡΕΣΤ.

Ε. Μ. ΠΟΛΥΤΕΧΝΕΙΟ
ΣΕΜΦΕ
ΤΟΜΕΑΣ ΜΗΧΑΝΙΚΗΣ

ΗΡ. ΠΟΛΥΤΕΧΝΕΙΟΥ 5,
ΖΩΓΡΑΦΟΥ-ΑΘΗΝΑ 157 73

ΤΗΛ 210 7721373

FAX 210 7721302

ΠΡΟΣΦΟΡΑ
No: 4-9028-3241
09 Φεβ 2004

ΘΕΜΑ DE-AIRING BLOCKS ΚΑΙ ΣΥΣΤΗΜΑ ΚΑΤΑΓΡΑΦΗΣ

ΣΧΕΤΙΚΑ

Εχουμε την ευχαριστηση να σας προσφερουμε τα ακολουθα ειδη που πιστευουμε οτι καλυπτουν τις απαιτησεις σας:

αα	ΠΟΣ		ΠΕΡΙΓΡΑΦΗ	ΜΟΝΑΔΑ	ΣΥΝΟΛΟ
1.	3	17029	De-Airing block for pressure transducers complete with on-off valve	113.63	340.89
2.				0.00	0.00
3.				0.00	0.00
4.				0.00	0.00
5.				0.00	0.00
6.				0.00	0.00
7.				0.00	0.00
8.				0.00	0.00
9.				0.00	0.00
10.				0.00	0.00

Γενικοι Οροι:

Χρονος Παραδοσης: 20-30 ημερες απο ληψεως της παραγγελιας, εκτος απο περιπτωσεις ανωτερας βιας

Τοπος Παραδοσης: ΑΘΗΝΑ

Προελευση: ΑΓΓΛΙΑ

Πληρωμη: 0 % Προκαταβολη με την παραγγελια
100 % τοις μετρητοις εντος 30 ημερων από την παράδοση

ΣΥΝΟΛΟ		340.89
	0.00	0.00
ΣΥΝΟΛΟ		**340.89**
ΦΠΑ 18%		61.36
ΣΥΝΟΛΟ	EURO	**402.25**

Ισοτιμία σε ΔΡΑΧΜΕΣ με ΦΠΑ *137 067*

Προμηθευτης:
WYKEHAM FARRANCE ENG., LTD. - UK

Εγκατασταση: Η παραδοση σε λειτουργια θα γινει ΔΩΡΕΑΝ απο την εταιρια μας.

Ισχυς: 30 ημερες.

Κρατησεις: Κρατήσεις δεν περιλαμβάνονται και καμία κράτηση δεν θα γίνει αποδεκτή αν δεν ενημερωθούμε.

1. Οι παραγγελιες επιβεβαιωνονται εγγραφως
2. Τα ειδη θα πρεπει να αποθηκευθουν ασφαλως μεχρι την παραλαβη των και να παραληφθουν εντος 10 ημερων.
3. Οι τιμες ισχυουν για το συνολο των προσφερομενων ανα ειδος μοναδων. Μερικος επιμερισμος μονον κατοπιν συμφωνιας.
4. Τα ειδη συνηθως καλυπτονται απο εγγυηση καλης λειτουργιας 12 μηνων απο την παραδοση. Αναλυτικοι οροι Εγγυησης διατιθενται απο την Εταιρια μας.
5. Οι όροι πληρωμής ισχύουν και για την παραγγελία, εκτός αν δηλωθεί διαφορετικά.
6. Τα ειδη παραμενουν στην κυριοτητα μας μεχρι τελικης εξοφλησης.

Ειμαστε στη διαθεση σας για οποιαδηποτε συμπληρωματικη πληροφορια ή διευκρινιση χρειαστειτε και σας ευχαριστουμε για το ενδιαφερον σας στα προϊοντα μας.

ΝΕΟΤΕΚ ΟΕ - Π. ΞΥΣΤΡΗΣ & Σια
Ελ. Βενιζέλου 105, Ν. Σμυρνη
ΑΘΗΝΑ 171 23
Τηλ: 210-9341533 & 9359142
Fax: 210-9359778

Παν. Νικολακόπουλος

FMT

Pressure Gauges

and Thermometers

FIMET

Fimet

11

Box: in galvanized steel
Ring: in chromium plated steel
Transparent: in glass kostil
Pressure gauge element: bimetallic spiral
Shank: centre back in galvanized steel
Sheath: in brass, 1/2 G
(3/8 G for TB 40)

Box: in chromium plated steel
Transparent: in kostil, release
Pressure gauge element: bimetallic spiral
Shank: radial in brass
Precision movement: clock, in brass
Sheath: in brass, 1/2 G

Box: in galvanized steel
Ring: in chromium plated steel
Transparent: in glass
Pressure gauge element: bimetallic spiral
Shank: centre back in galvanized steel
WITHOUT SHEATH

Back radial connection, 63 diameter, also available

Back radial connection, 100 diameter, also available

BIMETALLIC THERMOMETERS

DN 40 – DN 63 – DN 80 – DN 100 BACK

CODE	PACK	DESCRIPTION	SCALE	CON-NECT.	SUPPLIER CODE	€	LIT
200710	240	TB-40 30	0-80°C	3/8G	PT1A457002	5,83	11.290
200720	100	TB-63 50	0-60°C	1/2G	PT3A447001	6,03	11.670
200730°	100	TB-63 50	0-120°C	1/2G	PT3A507004	5,33	10.320
200740	50	TB-63 100	0-120°C	1/2G	PT3B507002	6,75	13.070
200750°	50	TB-80 50	-30+50°C	1/2G	PT4A987001	6,30	12.200
200760	50	TB-80 50	0-60°C	1/2G	PT4A447001	6,30	12.200
200770°	50	TB-80 50	0-120°C	1/2G	PT4A507002	5,66	10.950
200780	50	TB-80 100	-30+50°C	1/2G	PT4B987001	7,72	14.950
200790	50	TB-80 100	0-60°C	1/2G	PT4B447001	7,92	15.340
200810°	50	TB-80 100	0-120°C	1/2G	PT4B507002	6,80	13.170
200820	32	TB-100 50	-30+50°C	1/2G	PT5A987001	8,89	17.220
200830	32	TB-100 50	0-60°C	1/2G	PT5A447001	8,89	17.220
200840	32	TB-100 50	0-120°C	1/2G	PT5A507002	8,25	15.970
200850	32	TB-100 100	-30+50°C	1/2G	PT5B987001	10,89	21.080
200860	32	TB-100 100	0-60°C	1/2G	PT5B447001	10,89	21.080
200870	32	TB-100 100	0-120°C	1/2G	PT5B507002	10,29	19.920
		DN 80 RADIAL					
201110	50	TBR-80 14 75	-30+50°C	1/2G	PT8A987001	17,88	34.630
201100	50	TBR-80 14 75	0-60°C	1/2G	PT8A447001	17,88	34.630
201120°	50	TBR-80 14 50	0-120°C	1/2G	PT8A507001	17,11	33.130
201130	40	TBR-80 14 100	-30+50°C	1/2G	PT8B987001	19,48	37.710
201140	40	TBR-80 14 100	0-60°C	1/2G	PT8B447001	19,48	37.710
201150	40	TBR-80 14 100	0-120°C	1/2G	PT8B507001	18,90	36.600
		PYROMETER DN 63 FOR FUMES					
201710	50	TB-63 100	0-500°C		PT366870	6,30	12.200
201720	50	TB-63 150	0-500°C		PT376870	7,13	13.800
201730	40	TB-63 200	0-500°C		PT386870	7,62	14.760
201740	20	TB-63 300	0-500°C		PT396870	8,29	16.060
		PRESSURE GAUGES WITH STAINLESS STEEL BOX, SUBMERGED IN GLYCERINE					
		DN 63 RADIAL					
107110	50	**MG1-INOX 63** Box: in stainless steel Transparent: in polycarbonate with red hand Connection: radial in brass G1/4B Pressure gauge element: tubular spring in copper alloy	–1-0 BAR/inHG**	DN 63-G1/4B	PE309914LF	13,75	26.620
107111	50		–1+1.5 BAR/inHG*	DN 63-G1/4B	PE3502DJ00	13,75	26.620
107112	50		–1+3 BAR	DN 63-G1/4B	PE3504BJ01	13,75	26.620
107113	50		–1+5 BAR	DN 63-G1/4B	PE308722	13,75	26.620
107120	50		0-1 BAR/PSI**	DN 63-G1/4B	PE340114LF	12,48	24.160
107130	50		0-1,6 BAR/PSI**	DN 63-G1/4B	PE340214LF	12,48	24.160
107140	50		0-2,5 BAR/PSI**	DN 63-G1/4B	PE350314LF	10,71	20.740
107150	50		0-4 BAR/PSI**	DN 63-G1/4B	PE350414LF	10,71	20.740
107160	50		0-6 BAR/PSI**	DN 63-G1/4B	PE350614LF	10,71	20.740
107170	50		0-10 BAR/PSI**	DN 63-G1/4B	PE351014LF	10,71	20.740
107180	50		0-12 BAR/PSI**	DN 63-G1/4B	PE351214LF	10,71	20.740
107190	50		0-16 BAR/PSI**	DN 63-G1/4B	PE351614LF	10,71	20.740
107200	50		0-20 BAR/PSI**	DN 63-G1/4B	PE352014LF	10,71	20.740
107210	50		0-25 BAR/PSI**	DN 63-G1/4B	PE352514LF	10,71	20.740
107220	50		0-40 BAR/PSI**	DN 63-G1/4B	PE354014LF	10,71	20.740
107230	50		0-60 BAR/PSI**	DN 63-G1/4B	PE364414LF	12,11	23.440
107240	50		0-100 BAR/PSI**	DN 63-G1/4B	PE364814LF	12,11	23.440
107250	50		0-160 BAR/PSI**	DN 63-G1/4B	PE365414LF	12,11	23.440
107260	50		0-250 BAR/PSI**	DN 63-G1/4B	PE366014LF	12,11	23.440
107270	50		0-315 BAR/PSI**	DN 63-G1/4B	PE366214LF	12,11	23.440
107280	50		0-400 BAR/PSI**	DN 63-G1/4B	PE366614LF	12,11	23.440
107290	50		0-600 BAR/PSI**	DN 63-G1/4B	PE367014LF	12,11	23.440

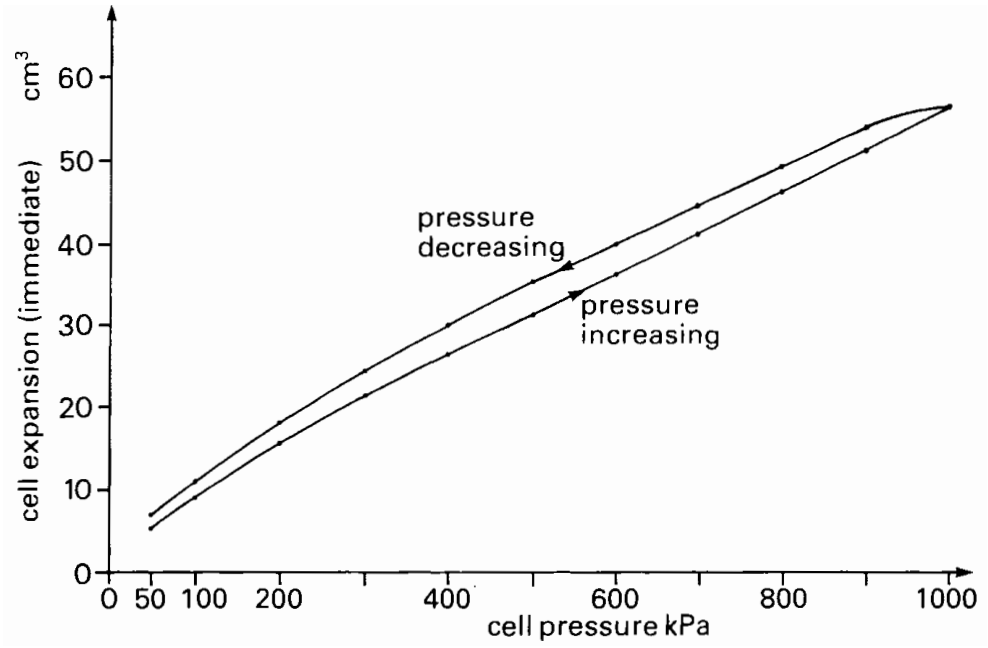


Figure 2.17: Typical curve of volume change of a triaxial chamber versus cell pressure (Head)

2.2 The WF chamber

To provide maximum visibility, the cell chamber is made from clear lucite-type material, which is stress relieved by Wykeham Farrance during manufacture. Lateral plastic strips are used to ensure high resistance in high cell pressure. The chamber is designed for water pressure only. The use of air as chamber pressure medium without water is highly dangerous.

In the case where the volume change of the specimen is measured indirectly (i.e. from the volume of the water coming in or out of the cell) the volume change - pressure curve of the triaxial chamber is needed. For this reason, calibration curves are usually given, in loading and unloading paths. Typical behavior of triaxial chambers is shown in Figure 2.17, while for the WF11001/SN:100257-9 triaxial cell, the calibration procedure showed that a mixed logarithmic/linear regression curve may well approximate its behavior under isotropic cell pressure (Figure 2.18).

$$V_{cell}\ [mm^3] = c_1 ln(\frac{\sigma_3}{\sigma_{3,0}}) + c_2(\sigma_3 - \sigma_{3,0}) \tag{2.1}$$

where $c_1 = 3940mm^3$, $c_2 = 31.2mm^3/kPa$ and $\sigma_{3,0} = 8.8kPa$

In the upper part of the chamber, a de-airing valve allows the user to extract air trapped in the upper part of the chamber. Such de-airing valve

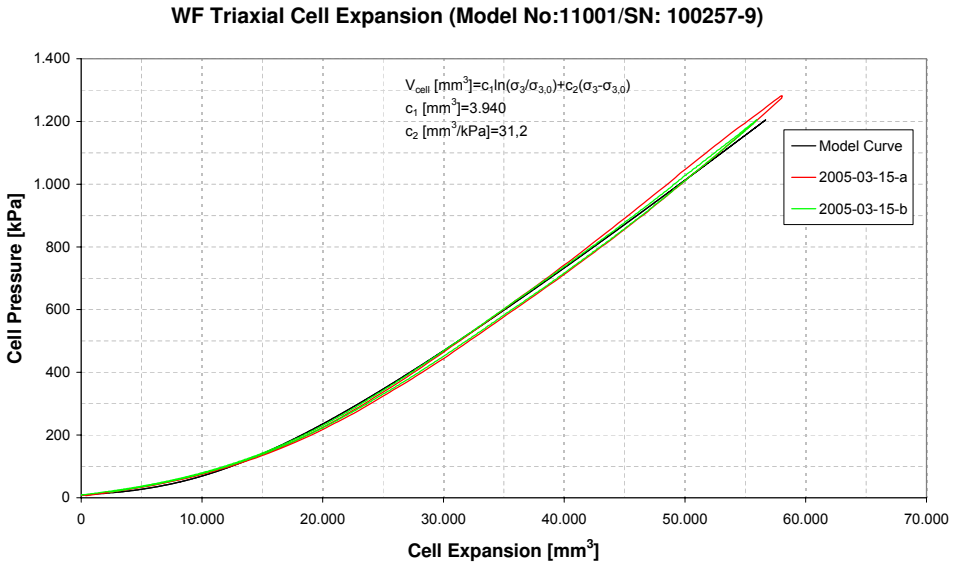


Figure 2.18: Calibration of WF11001/SN:100257-9 triaxial cell under isotropic pressure

may prove to be of great importance in case when the cell must be fully filled with water and no air is allowed to stay in the cell (i.e. calibration of cell, measurement of volume change). A mounting block (strain arm post) may also be installed on the upper part of the cell, in case the axial displacement of the specimen is externally measured (see Figure 2.19. A displacement transducer may be mounted either on the loading piston or on the vertical rods of the frame, while its spindle comes into contact with the upper part of the cell. Due to the lack of space for on-sample transducers, inside the chamber, a displacement transducer is externally mounted at the upper part of the cell. This is a LSC-HS50-9021 displacement transducer measuring the axial deformation of the specimen. Table 2.5 summarises the main specifications and calibration constants of this transducer.

The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the displacement transducer follows the below mentioned cabling: excitation voltage + (red), excitation voltage − (yellow), output voltage + (green), output voltage − (blue) and ground (shield).

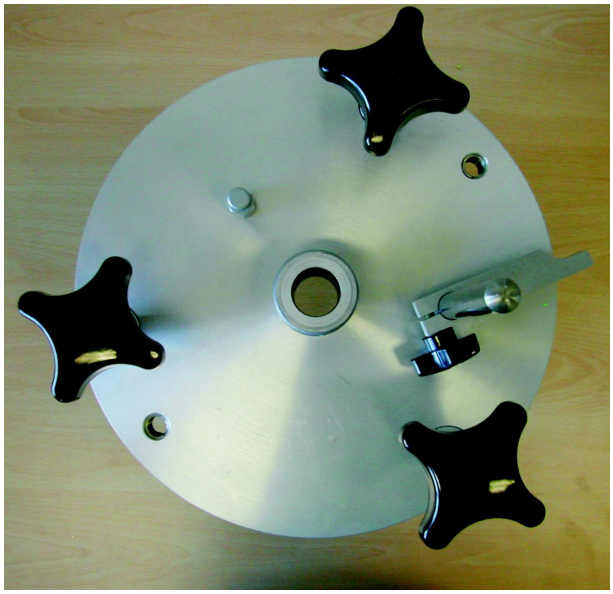
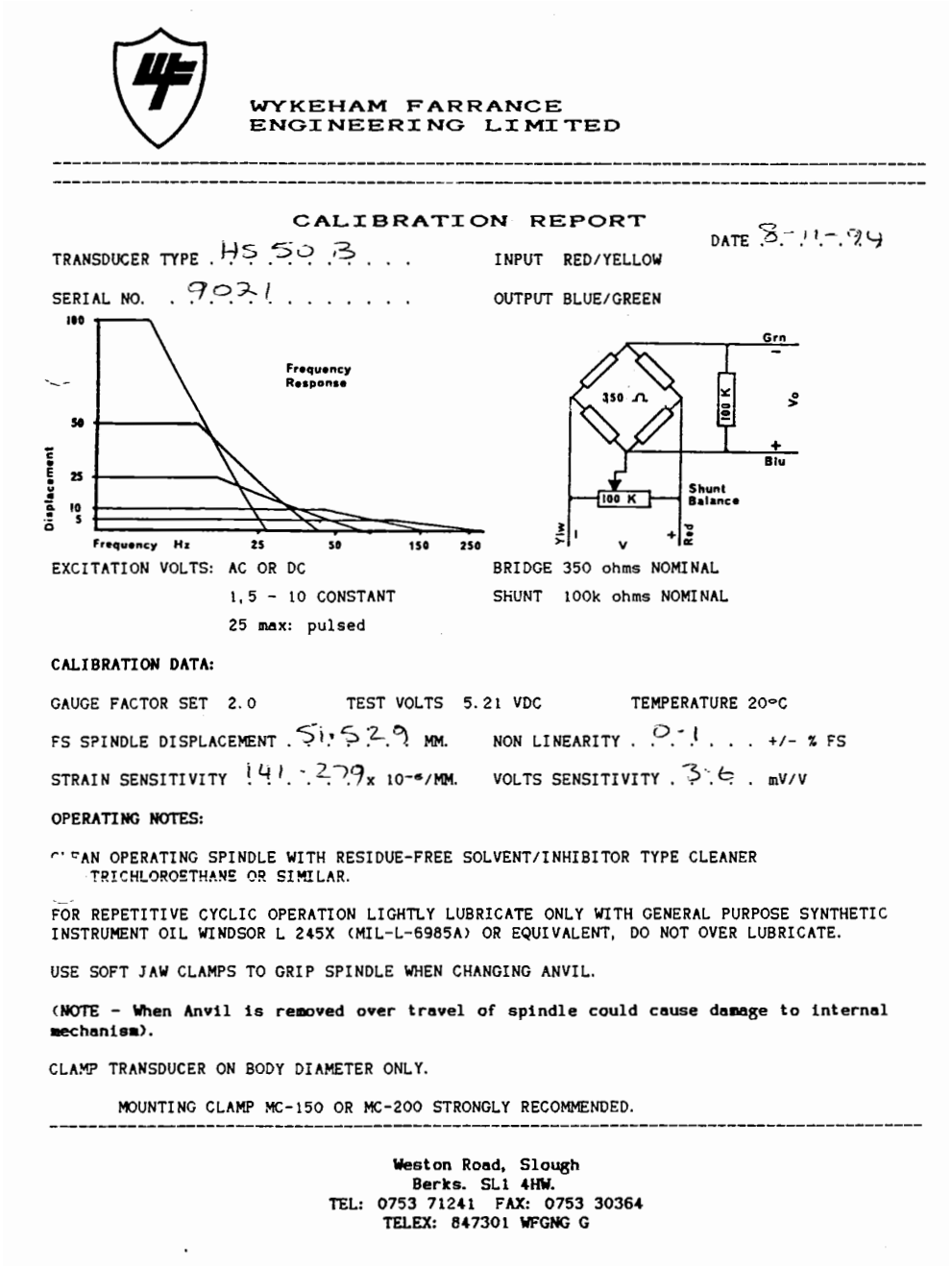


Figure 2.19: De-airing valve on top of WF triaxial cell and strain arm post

Operator	GIO	GIO
Place	GeoLab	GeoLab
Date	2004-06-01	2004-07-10
Time	16:00	16:50
Maximum spindle	-	51.62mm
Calibration constant	1.406mm/mV	1.414mm/mV
Linearity	99.998%	99.998%
Excitation voltage	10.00Volts	10.11Volts
Voltage Sensitivity	3.54mV/V	3.59mV/V
Sampling rate	1.000samples/sec	1.000samples/sec
Temperature	-	30.9^0
Humidity	-	29%

Table 2.5: LSC-HS50-9021 Specifications-Calibration Table



WYKEHAM FARRANCE
ENGINEERING LIMITED

CALIBRATION REPORT

DATE 8-11-94

TRANSDUCER TYPE . HS 50 3 . . .

INPUT RED/YELLOW

SERIAL NO. . 9021 . . . . . .

OUTPUT BLUE/GREEN

EXCITATION VOLTS: AC OR DC
1,5 - 10 CONSTANT
25 max: pulsed

BRIDGE 350 ohms NOMINAL
SHUNT 100k ohms NOMINAL

CALIBRATION DATA:

GAUGE FACTOR SET 2.0 TEST VOLTS 5.21 VDC TEMPERATURE 20°C

FS SPINDLE DISPLACEMENT . 5.1529 MM. NON LINEARITY . 0.1 . . . +/- % FS

STRAIN SENSITIVITY 141.279 x 10^{-6}/MM. VOLTS SENSITIVITY . 3.6 . mV/V

OPERATING NOTES:

CLEAN OPERATING SPINDLE WITH RESIDUE-FREE SOLVENT/INHIBITOR TYPE CLEANER
TRICHLOROETHANE OR SIMILAR.

FOR REPETITIVE CYCLIC OPERATION LIGHTLY LUBRICATE ONLY WITH GENERAL PURPOSE SYNTHETIC INSTRUMENT OIL WINDSOR L 245X (MIL-L-6985A) OR EQUIVALENT, DO NOT OVER LUBRICATE.

USE SOFT JAW CLAMPS TO GRIP SPINDLE WHEN CHANGING ANVIL.

(NOTE - When Anvil is removed over travel of spindle could cause damage to internal mechanism).

CLAMP TRANSDUCER ON BODY DIAMETER ONLY.

MOUNTING CLAMP MC-150 OR MC-200 STRONGLY RECOMMENDED.

Weston Road, Slough
Berks. SL1 4HW.
TEL: 0753 71241 FAX: 0753 30364
TELEX: 847301 WFGNG G

Figure 2.20: Wykeham Farrance axial displacement transducer reference manual, LSC-HS50-9021

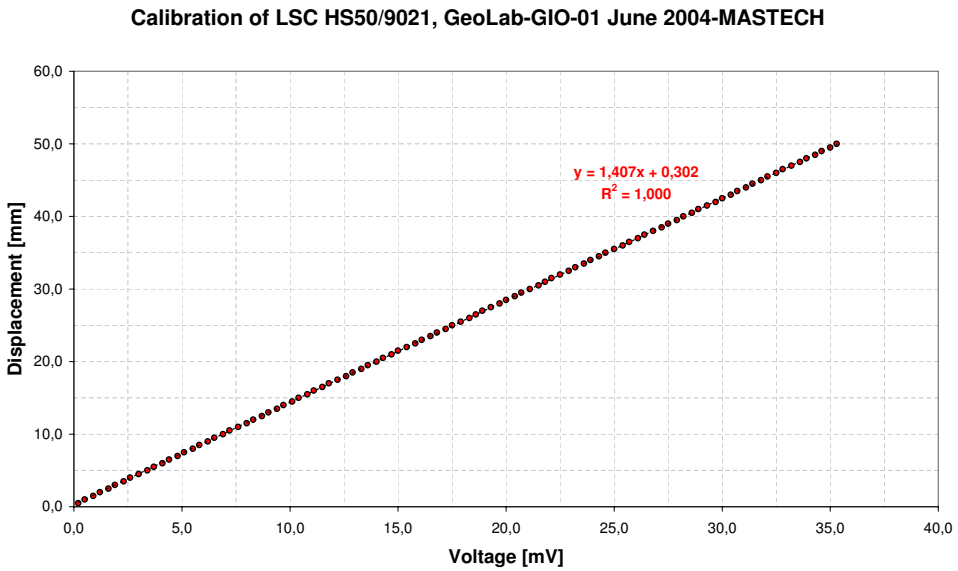


Figure 2.21: Wykeham Farrance axial displacement transducer calibration, 2004-06-01, LSC-HS50-9021

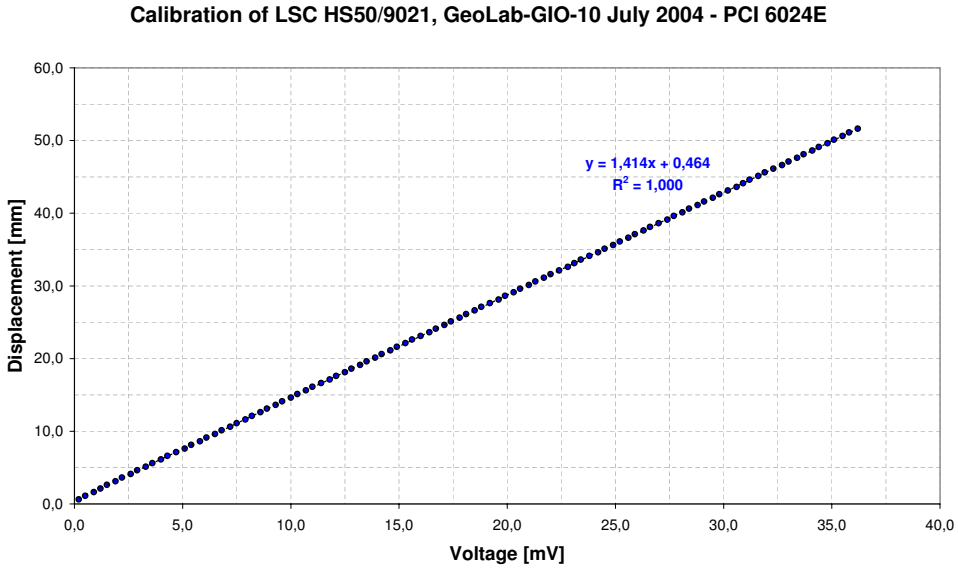


Figure 2.22: Wykeham Farrance axial displacement transducer calibration, 2004-07-10, LSC-HS50-9021

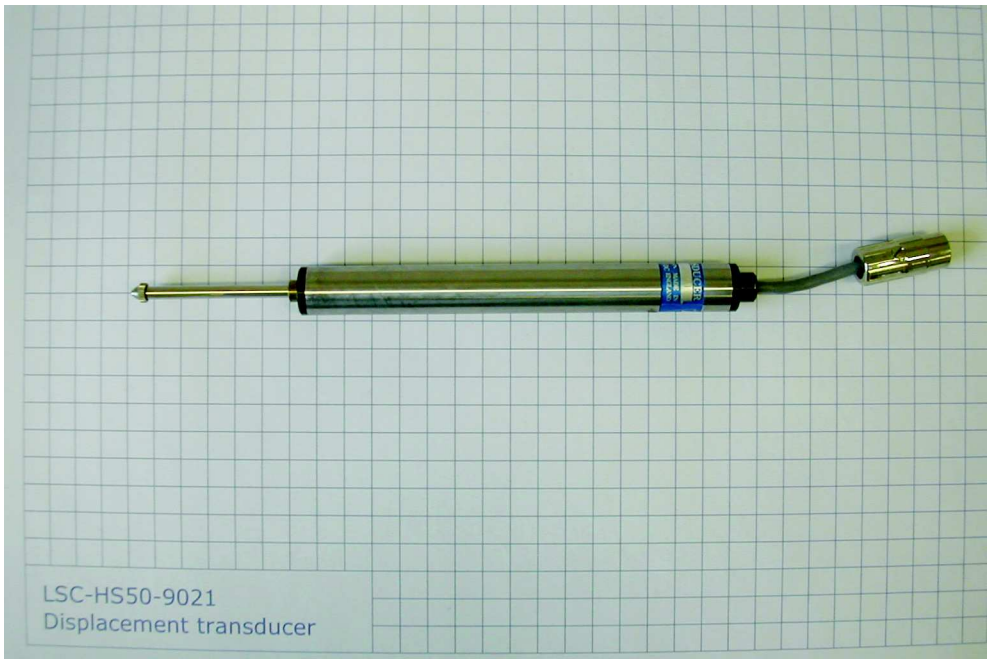


Figure 2.23: Wykeham Farrance axial displacement transducer LSC-HS50-9021

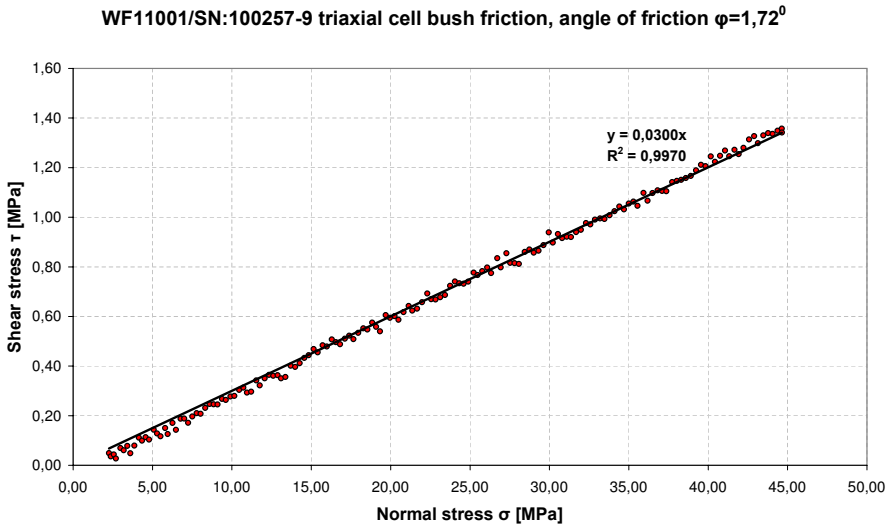


Figure 2.24: Friction developed in the sliding contact of the piston with the triaxial bush

A loading ram is also allowed to slide in the triaxial cell along the bush. The loading ram or piston is precision engineered and it is fitted into the cell with a low friction, low leakage assembly. The watertightness of the contact between the piston and the bush is achieved via an O-ring. The loading ram applies the axial force to the top cap of the specimen during a triaxial test. The axial force may be measured either by a load ring/cell outside the chamber or by a submersible load cell inside the chamber.

Although the piston can freely slide through the bush, there is always low friction appearing in the contact. In order to estimate the friction developed on the side contact surface of the loading ram and bush, the user may install one submersible load cell and one externally installed load cell and thus estimate the friction during a test (see Figure 2.24). Typical calibration tests performed for the WF triaxial cell give a rough estimation of the above friction. The friction depends on the axial compressive load, the O-ring installed in the bush and on the cell pressure. For this reason two 50kN compressive capacity load cells have been installed in the triaxial cell. The first one is an externally installed load cell, mounted on the reaction beam of the loading frame. It is a stainless steel fully welded "S" Beam tension and compression load cell, DBBSE-50kN Series (Applied Measurements Limited, Serial No: A2242). Table 2.6 summarises the specifications of the DBBSE-50kN-A2242 load cell. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the load cell follows the below mentioned cabling:

Operator	GIO & CHM	-
Place	GeoLab	-
Date	2004-09-06	-
Time	19:45	-
Maximum compressive load	50.0kN	-
Calibration constant	2.431kN/mV	-
Linearity	99.997%	-
Excitation voltage	10.05Volts	-
Voltage Sensitivity	2.023mV/V	-
Sampling rate	1.000samples/sec	-
Temperature	29.3^0	-
Humidity	33%	-

Table 2.6: DBBSE-50kN-A2242 External Load Cell Calibration Table

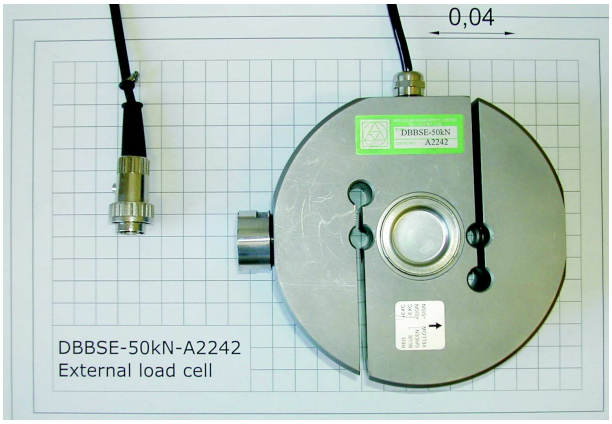
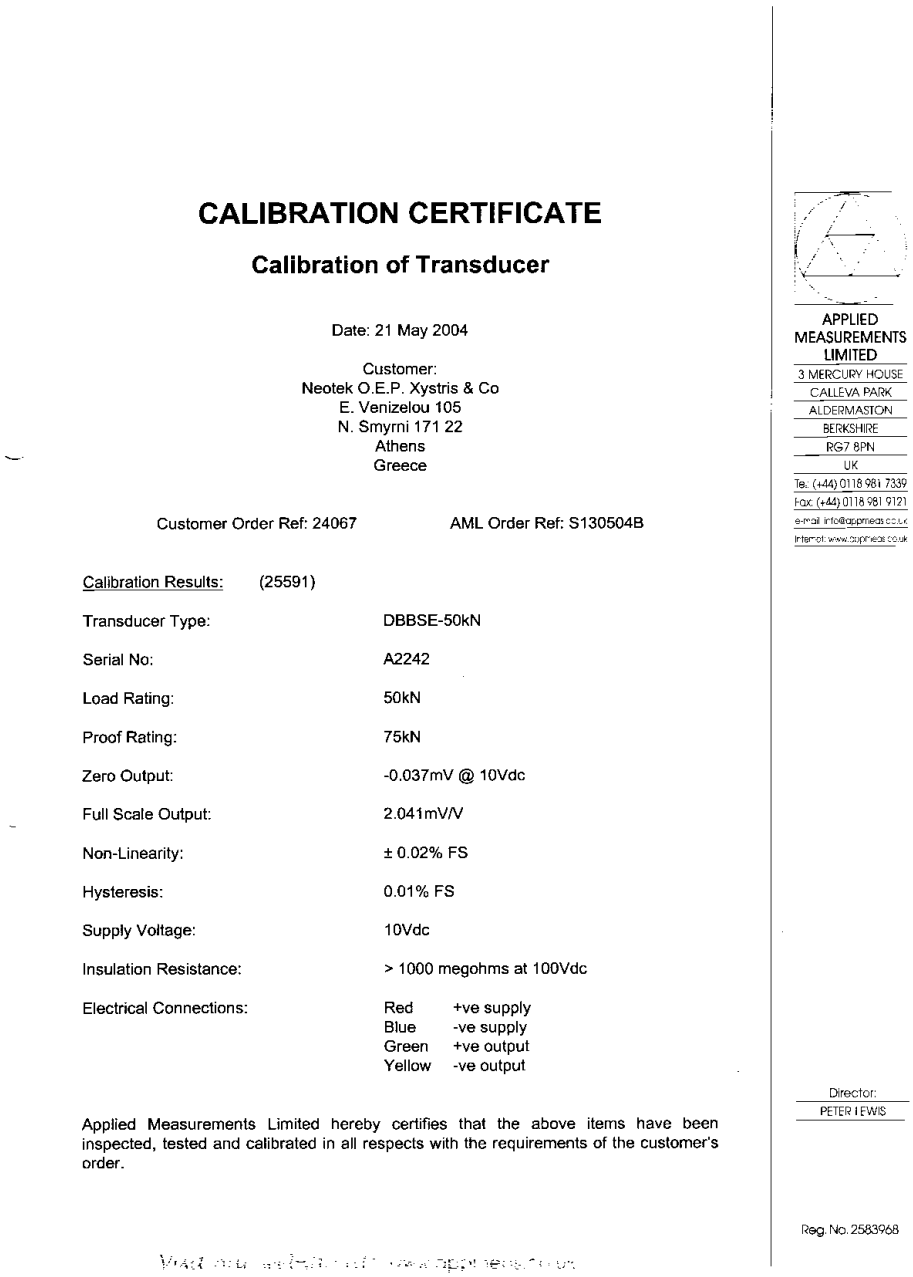


Figure 2.25: DBBSE-50kN-A2242 external load cell (Applied Ltd)

excitation voltage + (red), excitation voltage − (blue), output voltage + (green), output voltage − (yellow) and ground (shield).

In the following, more information and technical specifications concerning the DBBSE-50kN-A2242 external load cell are given through the Applied technical references and manuals.



CALIBRATION CERTIFICATE

Calibration of Transducer

Date: 21 May 2004

Customer:
Neotek O.E.P. Xystris & Co
E. Venizelou 105
N. Smyrni 171 22
Athens
Greece

Customer Order Ref: 24067 AML Order Ref: S130504B

Calibration Results: (25591)

Transducer Type:	DBBSE-50kN
Serial No:	A2242
Load Rating:	50kN
Proof Rating:	75kN
Zero Output:	-0.037mV @ 10Vdc
Full Scale Output:	2.041mV/V
Non-Linearity:	± 0.02% FS
Hysteresis:	0.01% FS
Supply Voltage:	10Vdc
Insulation Resistance:	> 1000 megohms at 100Vdc
Electrical Connections:	Red +ve supply Blue -ve supply Green +ve output Yellow -ve output

Applied Measurements Limited hereby certifies that the above items have been inspected, tested and calibrated in all respects with the requirements of the customer's order.

APPLIED MEASUREMENTS LIMITED
3 MERCURY HOUSE
CALLEVA PARK
ALDERMASTON
BERKSHIRE
RG7 8PN
UK
Tel: (+44) 0118 981 7339
Fax: (+44) 0118 981 9121
e-mail info@appmeas.co.uk
Internet www.appmeas.co.uk

Director:
PETER LEWIS

Reg. No. 2583968

Figure 2.26: DBBSE-50kN-A2242 external load cell reference manual

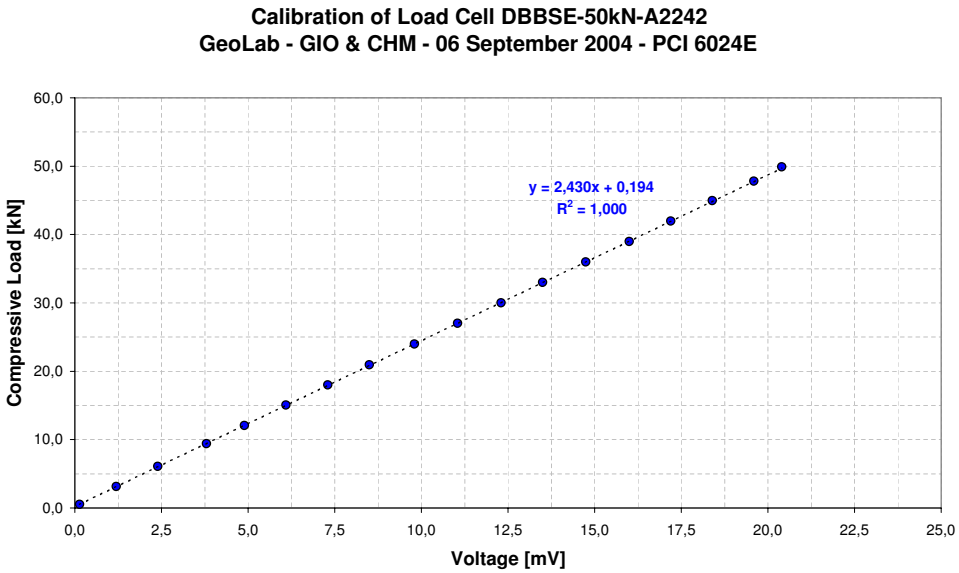


Figure 2.27: DBBSE-50kN-A2242 external load cell calibration, 2004-09-06

CALIBRATION CERTIFICATE

Calibration of Transducer

Date: 21 May 2004

Customer:
Neotek O.E.P. Xystris & Co
E. Venizelou 105
N. Smyrni 171 22
Athens
Greece

Customer Order Ref: 24067 AML Order Ref: S130504B

Calibration Results: (25591)

Transducer Type:	DBBSE-50kN
Serial No:	A2242
Load Rating:	50kN
Proof Rating:	75kN
Zero Output:	-0.037mV @ 10Vdc
Full Scale Output:	2.041mV/V
Non-Linearity:	± 0.02% FS
Hysteresis:	0.01% FS
Supply Voltage:	10Vdc
Insulation Resistance:	> 1000 megohms at 100Vdc
Electrical Connections:	Red +ve supply Blue -ve supply Green +ve output Yellow -ve output

Applied Measurements Limited hereby certifies that the above items have been inspected, tested and calibrated in all respects with the requirements of the customer's order.

APPLIED MEASUREMENTS LIMITED
3 MERCURY HOUSE
CALLEVA PARK
ALDERMASTON
BERKSHIRE
RG7 8PN
UK
Tel: (+44) 0118 981 7339
Fax: (+44) 0118 981 9121
e-mail info@appmeas.co.uk
Internet www.appmeas.co.uk

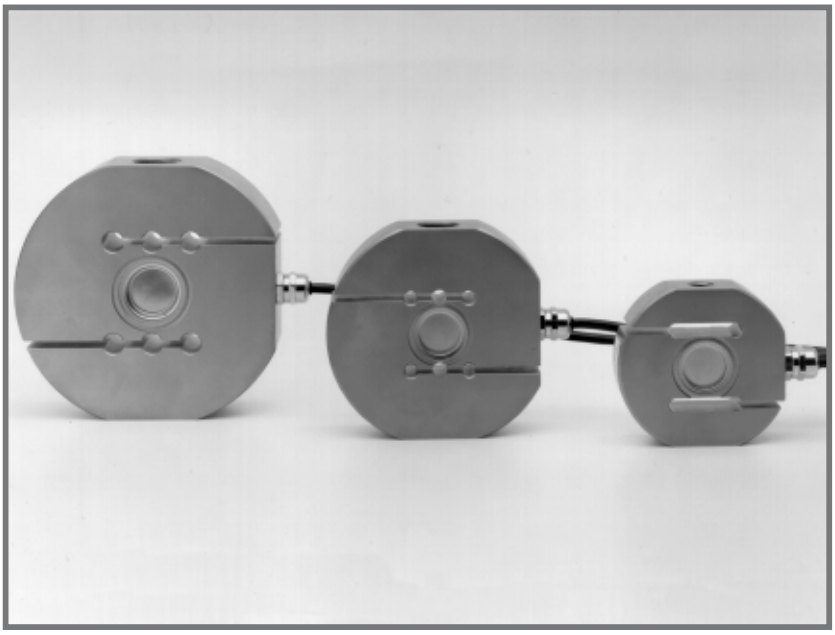
Director:
PETER LEWIS

Reg. No. 2583968

Stainless Steel Fully Welded
'S' Beam Tension and Compression

LOAD CELL

DBBSE Series



- **Capacities 10kg to 20,000kg**
- **Sealed to IP68**
- **High Accuracy**
- **Fully Welded Stainless Steel from 250kg**
- **Robust Construction**
- **High Side Load Resistance**
- **Simple Installation**
- **3 YEAR WARRANTY**

Options Available

Different Cable Lengths

Cable Conduit Fitting

Full range of mounting options available, including:-

- Shock/Anti-Vibration mounting assembly
- Load Button
- Spherical rod-end bearings

DESCRIPTION

The DBBSE series S-beam load cell is designed for force measurement and weighing applications alike. It's ease of mounting makes it very attractive for use as a general purpose load cell and is equally suited for laboratory and harsh environments due to it's fully welded stainless steel construction.

The DBBSE is ideally suited for weighing applications in food, pharmaceutical, brewing, or any other plant that requires regular wash down for hygienic reasons.

There are many options that are available to further enhance the usefulness of this series of load cells and to assist engineers with on site installation.

Applied Measurements also offer a wide range of Instrumentation to meet most weighing system requirements. We also offer a service, advising customers on their specific control requirements from the weighing system.

Transducer Specialists...

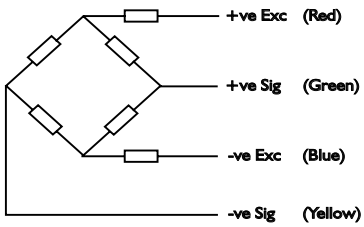
APPLIED MEASUREMENTS LIMITED

3 MERCURY HOUSE - CALLEVA PARK - ALDERMASTON - BERKSHIRE - RG7 8PN - UK

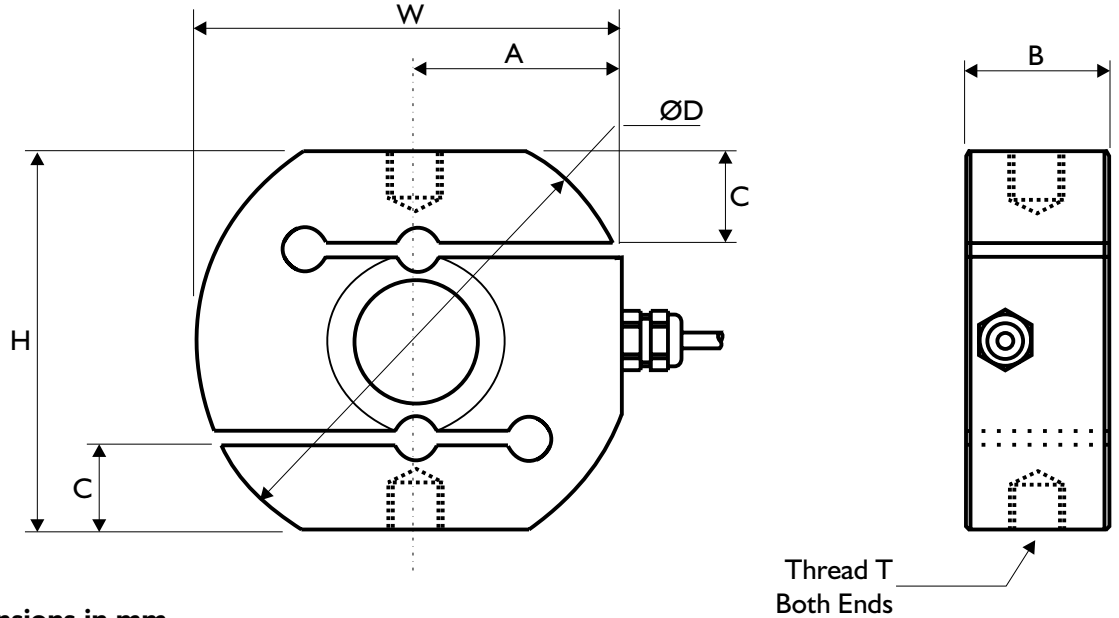
Tel: (+44) 0118 981 7339 Fax: (+44) 0118 981 9121 email: info@appmeas.co.uk Internet: www.appmeas.co.uk

SPECIFICATION

Wiring Schematic Diagram



CHARACTERISTICS	DBBSE	UNITS
Rated Capacities:	10, 25, 50, 100, 250, 500, 1000, 2000, 5000, 10,000, 20,000	kg
Rated Output:	2.0 ±0.1	mV/V
Accuracy:	<0.030	±% of Applied Load
Zero Return after 30 mins.:	<0.030	±% of Applied Load
Zero Balance:	<2.0	±% of Rated Output
Temperature Range Operating:	-20 to +80	°C
Compensated:	-10 to +40	°C
Temperature Effect On Output:	<0.0015	±% of Applied Load/°C
On Zero:	<0.002	±% of Rated Output/°C
Safe Overload:	150	% of Rated Capacity
Ultimate Overload:	300	% of Rated Capacity
Excitation Recommended:	10	VAC or VDC
Maximum:	15	VAC or VDC
Input Impedance:	410 ±20	Ohms
Output Impedance:	350 ±2	Ohms
Insulation Impedance:	>500	Megaohms
Deflection at Rated Load:	<0.4	mm
Weight (without cable):	10kg to 500kg (0.6kg), 1000kg to 2000kg (1.5kg), 5000kg (3.4kg), 10,000kg (6kg), 20,000kg (8.3kg)	kg
Construction:	Stainless Steel	
Environmental Protection:	IP65 upto 100kg IP68 from 250kg	
Cable:	3 Metre 4 Core Screened	



All dimensions in mm

RANGE (kg)	A	W	H	C	B	ØD	Thread T
10,25,50,100	35	72.5	70	16	18	75	M8 x 1.25
250, 500	35	72.5	70	16	24.5	75	M12 x 1.75
1000, 2000	45	95	95	28	30	100	M20 x 1.5
5000	57.5	120	120	34	40	125	M24 x 2
10,000	65	140	145	40	55	150	M30 x 2
20,000	90	190	190	60	75	200	M45 x 3

Continuous product development may result in minor changes to published specifications.

CALIBRATION CERTIFICATE

Calibration of Transducer

Date: 27 August 2004

Customer:
Neotek O.E.P. Xystris & Co
E. Venizelou 105
N. Smyrni 171 22
Athens
Greece

Customer Order Ref: 24112 AML Order Ref: S120704D

APPLIED MEASUREMENTS LIMITED
3 MERCURY HOUSE
CALLEVA PARK
ALDERMASTON
BERKSHIRE
RG7 8PN
UK
Tel: (+44) 0118 981 7339
Fax: (+44) 0118 981 9121
e-mail: info@appmeas.co.uk
Internet: www.appmeas.co.uk

Calibration Results: (25658)

Transducer Type:	CCG-200kN
Serial No:	25010
Load Rating:	200kN
Proof Rating:	300kN
Zero Output:	-0.129mV @ 10Vdc
Full Scale Output:	1.247mV/V
Non-Linearity:	± 0.19% FS
Hysteresis:	0.14% FS
Supply Voltage:	10Vdc
Insulation Resistance:	> 1000 megohms at 100Vdc
Electrical Connections:	Red +ve supply Blue -ve supply Green +ve output Yellow -ve output

Applied Measurements Limited hereby certifies that the above items have been inspected, tested and calibrated in all respects with the requirements of the customer's order.

Director:
PETER LEWIS

Reg. No. 2583968

CALIBRATION CERTIFICATE

Calibration of Transducer with Instrumentation

Customer:
Neotek OEP Xystris & Co
E. Venizelou 105
N. Smyrni 171 22
Athens
Greece

Date: 27 August 2004

Customer Order Ref: 24112

AML Order Ref: S120704D

APPLIED MEASUREMENTS LIMITED
3 MERCURY HOUSE
CALLEVA PARK
ALDERMASTON
BERKSHIRE
RG7 8PN
UK
Tel: (+44) 0118 981 7339
Fax: (+44) 0118 981 9121
e-mail: info@appmeas.co.uk
Internet: www.appmeas.co.uk

Transducer Type: DBBSE-5T Serial Number: A2288

Instrumentation Type: Tracker 211-E-B-1-R Serial Number: 07040077

Supply Voltage: 240Vac, 50Hz

Instrumentation calibration engineering units: kiloNewtons (kN)

Number of Decimal Places: Two

Options Fitted: Dual trip

Calibration carried out by: DRC

Calibration Results: Load applied in compression
Calibration traceable to National Standards
Traceable standard last calibrated August 2002

Load applied in Compression

Load Applied kN	Display Reading kN
0	0
10	10.00
20	20.00
30	30.00
40	40.00
50	50.00

Connections:

DBBSE Cable		Tracker Input Terminal
Red	(+ve Exc)	7
Blue	(-ve Exc)	6 & 8 Linked
Yellow	(+ve Signal)	12
Green	(-ve Signal)	13

Applied Measurements Limited hereby certifies that the above items have been inspected, tested and calibrated - using NAMAS traceable test equipment - in all respects with the requirements of the customer's order.

Director:
PETER LEWIS

Reg. No. 2583968

NEOTEK
Συστήματα Δοκιμών & Μετρήσεων
Measuring & Testing Systems
ISO 9001:2000 UKAS 047

Υπ' οψιν κ.
ΣΤΑΜΙΡΗ Μ.

Ε. Μ. ΠΟΛΥΤΕΧΝΕΙΟ
ΣΕΜΦΕ
ΤΟΜΕΑΣ ΜΗΧΑΝΙΚΗΣ
ΑΝΤΟΧΗ ΥΛΙΚΩΝ
ΗΡ. ΠΟΛΥΤΕΧΝΕΙΟΥ 5,
ΖΩΓΡΑΦΟΥ-ΑΘΗΝΑ 157 73

ΤΗΛ 210 7721231
FAX 210 7721302

ΠΡΟΣΦΟΡΑ
No: 4-818-3053
13 Νοε 2003

ΘΕΜΑ ΔΥΝΑΜΟΚΥΨΕΛΗ ΚΑΙ ΠΑΡΕΛΚΟΜΕΝΑ

ΣΧΕΤΙΚΑ

Εχουμε την ευχαριστηση να σας προσφερουμε τα ακολουθα ειδη που πιστευουμε οτι καλυπτουν τις απαιτησεις σας:

αα	ΠΟΣ		ΠΕΡΙΓΡΑΦΗ	ΜΟΝΑΔΑ	ΣΥΝΟΛΟ
1.	1	OBBSE	"S" Type Load Cell, 50kN (5000kg)	712.13	712.13
2.	1		Load Button for load cell	161.74	161.74
3.	1		Mounting adaptor for triaxial frame	96.56	96.56
4.	1	243	Tracker 240 Series Indicator, **5 digit**, 10VDC T'cer supply, Analogue output, Status inputs, RS422/485 communications	639.71	639.71
5.			(αντιστοιχούν από ένα S-type load cell 50kN)	0.00	0.00
6.				0.00	0.00
7.				0.00	0.00
8.				0.00	0.00
9.				0.00	0.00
10.				0.00	0.00

Γενικοι Οροι:

Χρονος Παραδοσης: 45 ημερες απο ληψεως της παραγγελιας, εκτος απο περιπτωσεις ανωτερας βιας

Τοπος Παραδοσης: ΑΘΗΝΑ

Προελευση: ΑΓΓΛΙΑ

Πληρωμη: 0 % Προκαταβολη με την παραγγελια
100 % τοις μετρητοις εντός 30 ημερών από την παράδοση

Οι όροι πληρωμής ισχύουν και για την παραγγελία, εκτός αν δηλωθεί διαφορετικά. Τα είδη παραμένουν στην κυριότητά μας μέχρι τελικής εξόφλησης.

Εγκατασταση: Η παραδοση σε λειτουργια θα γινει ΔΩΡΕΑΝ απο την εταιρια μας.

Ισχυς: 30 ημερες.

Κρατησεις: Κρατησεις περιλαμβανονται.

1. Οι παραγγελιες επιβεβαιωνονται εγγραφως
2. Τα ειδη θα πρεπει να αποθηκευθουν ασφαλως μεχρι την παραλαβη των και να παραληφθουν εντος 10 ημερων.
3. Οι τιμες ισχυουν για το συνολο των προσφερομενων ανα ειδος μοναδων. Μερικος επιμερισμος μονον κατοπιν συμφωνιας.
4. Τα ειδη συνηθως καλυπτονται απο εγγυηση καλης λειτουργιας 12 μηνων απο την παραδοση. Αναλυτικοι οροι Εγγυησης διατιθενται απο την Εταιρια μας.
5. Αξιες ανω των Ε 15.000 πληρωνονται με δίγραμμη επιταγή του πελάτη.
6.

ΣΥΝΟΛΟ		1 610.14
	0.00	0.00
ΣΥΝΟΛΟ		**1 610.14**
ΦΠΑ 18%		289.83
ΣΥΝΟΛΟ	EURO	**1 899.97**

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Προμηθευτης:
APPLIED MEASUREMENTS LTD.-UK

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ΝΕΟΤΕΚ ΟΕ - Π. ΞΥΣΤΡΗΣ & Σια
Ελ. Βενιζέλου 105, Ν. Σμυρνη
ΑΘΗΝΑ 171 23
Τηλ: 210-9341533 & 9359142
Fax: 210-9359778

Π. Ξύστρης

NEOTEK

Συστηματα Δοκιμων & Μετρησεων απο το 1969
Measuring & Testing Systems since 1969

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ΣΕΜΦΕ
ΤΟΜΕΑΣ ΜΗΧΑΝΙΚΗΣ
ΑΝΤΟΧΗ ΥΛΙΚΩΝ
ΗΡ. ΠΟΛΥΤΕΧΝΕΙΟΥ 5,
ΖΩΓΡΑΦΟΥ-ΑΘΗΝΑ 157 73

ΤΗΛ 210 7721373
FAX 210 7721302
ΘΕΜΑ
ΣΧΕΤΙΚΑ

ΠΡΟΣΦΟΡΑ
No: 4-8829-2632
30 Ιουν 2003

Εχουμε την ευχαριστηση να σας προσφερουμε τα ακολουθα ειδη που πιστευουμε οτι καλυπτουν τις απαιτησεις σας:

αα	ΠΟΣ		ΠΕΡΙΓΡΑΦΗ	ΜΟΝΑΔΑ	ΣΥΝΟΛΟ
1.	1	DBBSE	"S" Type Load Cell, 50kN (5000kg)	678.50	678.50
2.	1		Load Button for load cell	154.10	154.10
3.	1		Mounting adaptor for triaxial frame	92.00	92.00
4.	1	243	Tracker 240 Series Indicator, **5 digit**, 10VDC T'cer supply, Analogue output, Status inputs, RS422/485 communications	609.50	609.50
5.	1		Housing box for Tracker 240	69.00	69.00
6.				0.00	0.00
7.				0.00	0.00
8.				0.00	0.00
9.				0.00	0.00
10.				0.00	0.00

ΣΥΝΟΛΟ 1 603.10
0.00 0.00
ΣΥΝΟΛΟ **1 603.10**
ΦΠΑ 18% 288.56

ΣΥΝΟΛΟ EURO **1 891.66**

Ισοτιμία σε ΔΡΑΧΜΕΣ με ΦΠΑ *644 582*

Προμηθευτης:
APPLIED MEASUREMENTS LTD.-UK

Γενικοι Οροι:

Χρονος Παραδοσης: 45 ημερες απο ληψεως της παραγγελιας, εκτος απο περιπτωσεις ανωτερας βιας

Τοπος Παραδοσης: ΑΘΗΝΑ

Προελευση: ΑΓΓΛΙΑ

Πληρωμη: 0 % Προκαταβολη με την παραγγελια
100 % τοις μετρητοις εντος 30 ημερων από την παράδοση

Οι όροι πληρωμής ισχύουν και για την παραγγελία, εκτός αν δηλωθεί διαφορετικά. Τα είδη παραμένουν στην κυριότητά μας μέχρι τελικής εξόφλησης.

Εγκαταστση: Η παραδοση σε λειτουργια θα γινει ΔΩΡΕΑΝ απο την εταιρια μας.

Ισχυς: 30 ημερες.

Κρατησεις: Κρατησεις δεν περιλαμβανονται και καμια κρατηση δεν θα γινει δεκτη πλην του αναλογουντος φορου

1. Οι παραγγελιες επιβεβαιωνονται εγγραφως
2. Τα ειδη θα πρεπει να αποθηκευθουν ασφαλως μεχρι την παραλαβη των και να παραληφθουν εντος 10 ημερων.
3. Οι τιμες ισχυουν για το συνολο των προσφερομενων ανα ειδος μοναδων. Μερικος επιμερισμος μονον κατοπιν συμφωνιας.
4. Τα ειδη συνηθως καλυπτονται απο εγγυηση καλης λειτουργιας 12 μηνων απο την παραδοση. Αναλυτικοι οροι Εγγυησης διατιθενται απο την Εταιρια μας.
5. Αξιες ανω των Ε 15.000 πληρωνονται με δίγραμμη επιταγή του πελάτη.
6.

Ειμαστε στη διαθεση σας για οποιαδηποτε συμπληρωματικη πληροφορια ή διευκρινιση χρειαστειτε και σας ευχαριστουμε για το ενδιαφερον σας στα προϊοντα μας.

NEOTEK ΟΕ - Π. ΞΥΣΤΡΗΣ & Σια
Ελ. Βενιζέλου 105, Ν. Σμυρνη
ΑΘΗΝΑ 171 23
Τηλ: 210-9341533 & 9359142
Fax: 210-9359778

Π. Ξύστρης

Operator	GIO & CHM	-
Place	GeoLab	-
Date	2004-10-29	-
Time	17:30	-
Maximum compressive load	50.0kN	-
Calibration constant	2.374kN/mV	-
Linearity	99.999%	-
Excitation voltage	10.05Volts	-
Voltage Sensitivity	2.046mV/V	-
Sampling rate	1.000samples/sec	-
Temperature	25.0^0	-
Humidity	55%	-

Table 2.7: STALC3-50kN-24937 Submersible Load Cell Calibration Table

A submersible load cell is also installed in the triaxial cell, to provide more accurate estimation of the axial force applied to the specimen. A STALC3-50kN-24937 WF submersible load cell is mounted on the lower part of the loading ram, inside the triaxial cell. Table 2.7 summarises the specifications of the STALC3-50kN load cell. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the load cell follows the below mentioned cabling: excitation voltage + (red), excitation voltage − (blue), output voltage + (green), output voltage − (yellow) and ground (shield).

In the following, more information and technical specifications concerning the STALC3-50kN-24937 submersible load cell are given through the WF technical references and manuals.

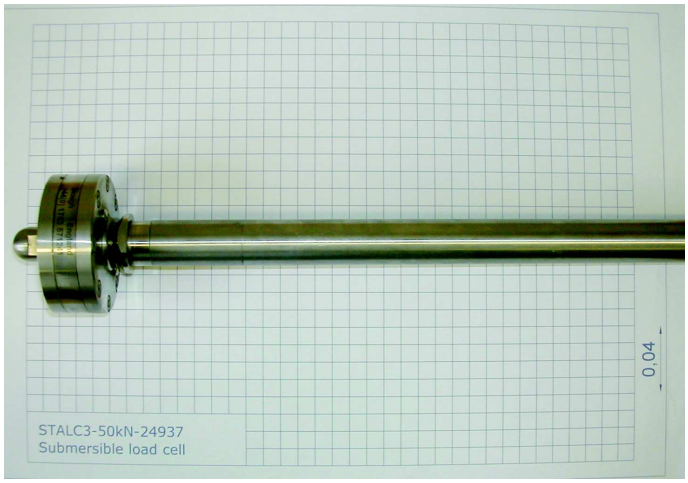


Figure 2.28: Wykeham Farrance STALC3-50kN triaxial submersible load cell

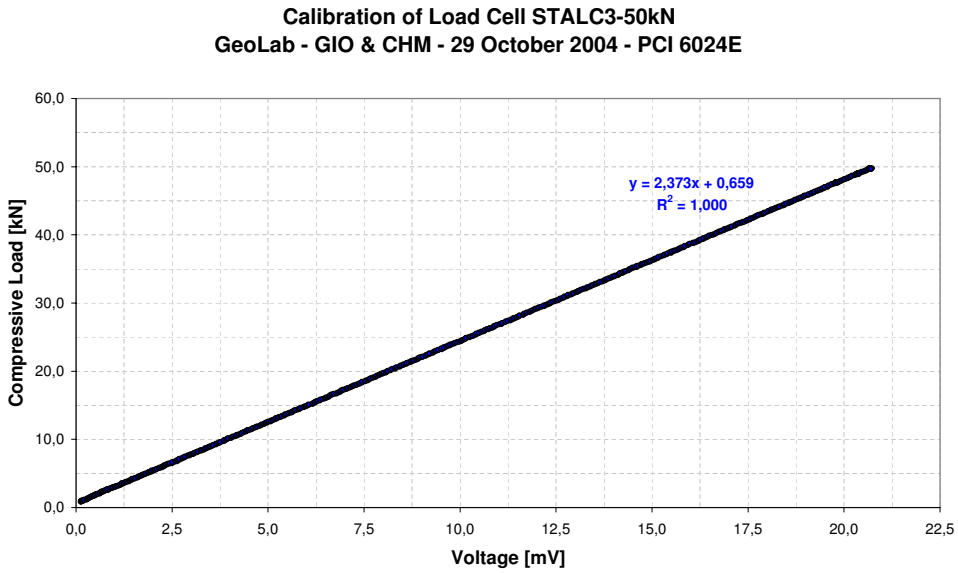
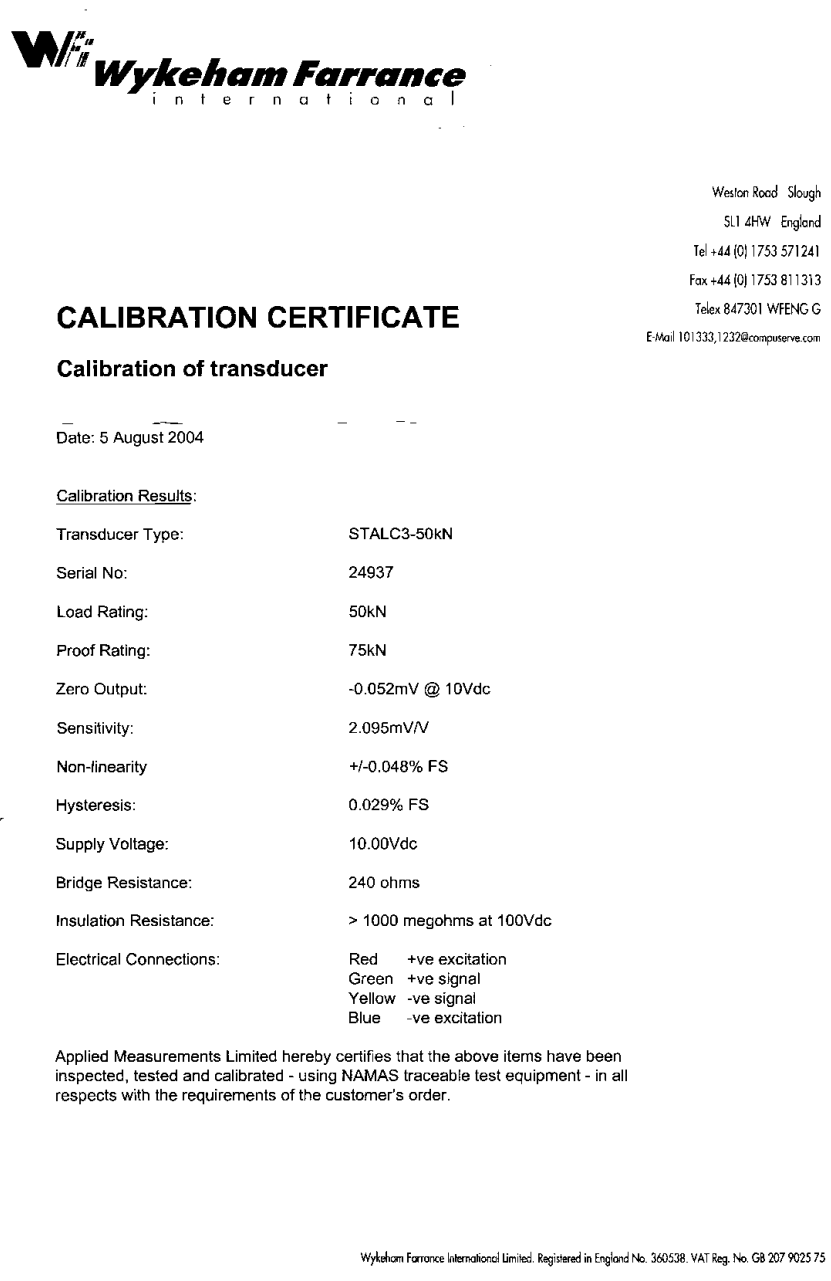


Figure 2.29: STALC3-50kN-24937 submersible load cell calibration, 2004-10-29



Wykeham Farrance
international

Weston Road Slough
SL1 4HW England
Tel +44 (0) 1753 571241
Fax +44 (0) 1753 811313
Telex 847301 WFENG G
E-Mail 101333,1232@compuserve.com

CALIBRATION CERTIFICATE

Calibration of transducer

Date: 5 August 2004

Calibration Results:

Transducer Type:	STALC3-50kN
Serial No:	24937
Load Rating:	50kN
Proof Rating:	75kN
Zero Output:	-0.052mV @ 10Vdc
Sensitivity:	2.095mV/V
Non-linearity	+/-0.048% FS
Hysteresis:	0.029% FS
Supply Voltage:	10.00Vdc
Bridge Resistance:	240 ohms
Insulation Resistance:	> 1000 megohms at 100Vdc
Electrical Connections:	Red +ve excitation Green +ve signal Yellow -ve signal Blue -ve excitation

Applied Measurements Limited hereby certifies that the above items have been inspected, tested and calibrated - using NAMAS traceable test equipment - in all respects with the requirements of the customer's order.

Wykeham Farrance International Limited. Registered in England No. 360538. VAT Reg. No. GB 207 9025 75

Figure 2.30: STALC3-50kN-24937 submersible load cell reference manual

Wykeham Farrance
international

Weston Road Slough
SL1 4HW England
Tel +44 (0) 1753 571241
Fax +44 (0) 1753 811313
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Applied Measurements Limited hereby certifies that the above items have been inspected, tested and calibrated - using NAMAS traceable test equipment - in all respects with the requirements of the customer's order.

Strain Gauge Based Submersible Triaxial

LOAD CELL

STALC Series

- **Capacities 1kN to 50kN**
- **Fully submersible to an external pressure of up to 70bar**
- **Pressure Compensated Design**
- **Robust Construction**
- **Simple Installation**
- **High Performance**
- **High Sideload Tolerance**
- **3 YEAR WARRANTY**

Options Available

Other Ranges Available on request

Equivalents to other manufacturers' available

Different Cable Lengths

DESCRIPTION

The STALC series of submersible triaxial load cells has been designed for measuring compressive loads from 1kN to 50kN. The products can be fitted into new or existing triaxial cells with a diameter up to 100mm.

The design features an internal pressure compensation system that eliminates zero offset changes when the load cell is subjected to external pressure changes. Being insensitive to cell confining pressure, the load cell can be used inside the triaxial cell - the load also being measured within the cell eliminates the effects of piston friction.

The use of specially selected heat treated stainless steel and precision strain gauges ensure optimum performance and excellent long term stability.

Transducer Specialists...

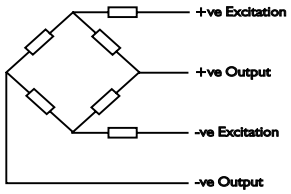
APPLIED MEASUREMENTS LIMITED

3 MERCURY HOUSE - CALLEVA PARK - ALDERMASTON - BERKSHIRE - RG7 8PN - UK

Tel: (+44) 0118 981 7339 Fax: (+44) 0118 981 9121 email: info@appmeas.co.uk Internet: www.appmeas.co.uk

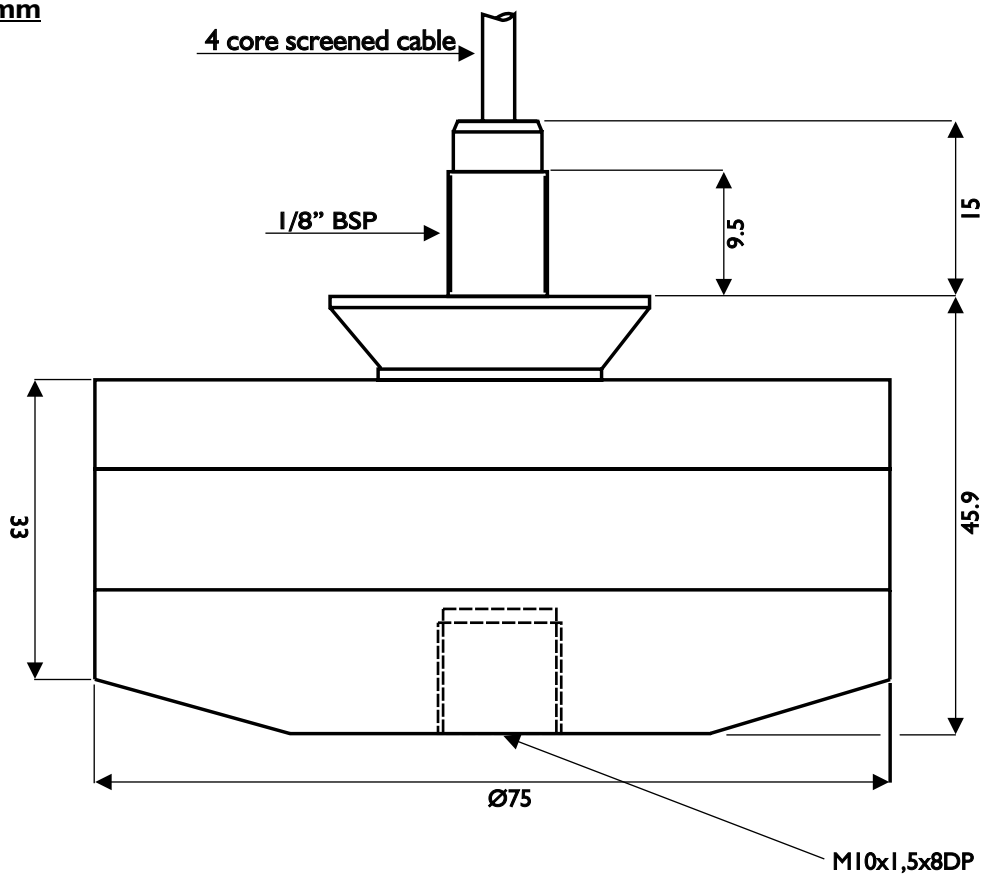
SPECIFICATION

Wiring Schematic Diagram



CHARACTERISTICS	STALC	UNITS
Rated Capacities:	1, 3, 5, 10, 25, 50, 100	KN
Rated Output:	2.0 nominal	mV/V
Non-linearity:	<0.05	±% of Full Scale
Hysteresis:	<0.1	±% of Full Scale
Temperature Range: Operating	-20 to +80	°C
Compensated	0 to 50	°C
Temperature Effect: On Output	<0.01	±% of FSO/ °C
On Zero	<0.02	±% of FSO/ °C
Safe Overload:	150	% of Rated Capacity
Ultimate Overload:	300	% of Rated Capacity
Excitation: Recommended	10	Volts AC or DC
Maximum	15	Volts AC or DC
Input Impedance:	260 nominal	Ohms
Output Impedance:	240 nominal	Ohms
Insulation Impedance:	>2000 (bridge to ground) & >1000 (shield to ground)	Megaohms
Deflection at Rated Capacity:	<0.05	mm
Weight:	0.85	Kg
Construction:	Stainless Steel	
Environmental Protection:	Fully submersible to 7000kPa	
Cable:	3 Metre 4 Core Screened	

All dimensions in mm



APPLIED MEASUREMENTS LIMITED

Issue 07/04

Continuous product development may result in minor changes to published specifications.

Wykeham Farrance international

Solution

Data Acquisition

BS

Information

WF17100 to WF17117 and WF72258 Internal Load Cells

AASHTO

Quality

Reliability

Testing Solutions

Wykeham Farrance International

1700 kPa

3400 kPa

Triaxial Load

50kN

Fatigue

Sales

British Standard

ASTM

A Total Solution Provider

WYKEHAM FARRANCE LOADMASTER LOAD CELLS

WF17100 SERIES.

A3.00 **INTRODUCTION**

This Appendix describes the use of the following Wykeham Farrance products:

It is written as an appendix to the Wykeham Farrance CLISP software manual. However, it is a self contained doucment and is also used as a separate instruction and operating manual for these products.

These load cells have been specifically designed by Wykeham Farrance for load measurement inside triaxial cells, in order to eliminate the frictional load loss incurred by external load measurement.

The design is based on the use of strain gauged flanged web, whose gauges are connected in such a way as to provide a signal proportional to the vertical load applied to the sample, even if this load is not collinear with the specimen axis, and to be insensitive to the fluid pressure with the triaxial cell.

The strain gauges are chosen to be self-compensating for temperature changes, however, an additional precaution is taken by providing a wiring configuration which ensures that even if some mismatch of the gauge coefficient occurs, the system is self-compensating for temperature changes. They can also be used externally under normal atmospheric conditions for such applications as direct shear or ring shear.

These load cells are fitted with an O ring seal which seals against the triaxial cell piston. The load cells **ARE NOT** locked into place with a sealing compound. They can therefore be moved

from cell to cell should the need arise. However, the greatest care must be exercised when handling load cells as they are precision made scientific instruments.

Unlike earlier generations of load cells, the WF17100 series have an over load capacity of 200 per cent. However, **WE DO NOT RECOMMEND** that these load cells are **INTENTIONALLY OVERLOADED.**

Another improvement over earlier generation of load cells is the fact that the cable can be resoldered into place if accidentally broken.

A.3.0.1 **TECHNICAL SPECIFICATION**

MECHANICAL		**RANGES AVAILABLE**
Nominal Diameter	76 mm	500 kgf 5kN
Nominal Height	30 mm	1000 kgf 10kN
		2500 kgf 25kN

A.3.0.2 **ELECTRICAL**

Excitation 10v D.C./15 vdc max

Input resistance 385 ohms output resistance 350 ohms

Output range 2mV/v nominal

Non-linearity nominally +/- 0.5 per cent full scale max

Thermal Sensitivity shift 0.01 per cent FS / degree C max

Hysteresis 0.05 per cent FS max

ENVIRONMENTAL

Operating temperature range 0 degree to + 50 degree C

Pressure range up to 70 MN/m2

These units will operate in any environment compatible with 18/8 and EN57 stainless steel.

A.3.0.4 **CALIBRATION OF LOAD CELLS**

The most accurate method of calibrating these load cells is to use the WF14450 dead weight calibrating frame. Detailed instructions for calibrating load cells with the dead weight are supplied with the device. The following instructions apply to those organisations that do not possess a suitable dead weight calibrator. In the absence of a calibrating frame, the load cell may be calibrated using a load ring and 50kN stepless triaxial compression machine, In one of two ways:-

1. The Load Cell should be connected to the readout unit and allowed to warm-up for 24 hours.

2. A steel block is substituted for a sample in the triaxial cell.

3. With the load cell under conditions of zero load the readout device which may be a 17135 data acquisition system, WF18000 series interface or other suitable instrument is adjusted to read the channel allocated to the load cell being calibrated. Using the zero adjustment screw control (zero pot) the data is adjusted to read zero.

4. It is very important that the load applied has been calculated correctly using the load ring calibration figures and that the exact correct number of divisions of load ring movement are applied.

5. The load on the load cell is then slowly increased to the rated maximum for the particular load cell. It is of course of vital importance that the correct load is applied, at this stage we therefore strongly advise that the CAPACITY of the load cell is checked.

6. When the maximum load is reached the compression machine is stopped and the data display is adjusted to read the maximum value in kgf using the span or "gain" screw control (span pot).

7. The load is now slowly decreased until a zero load condition is reached. The data display is again adjusted to read zero

using a zero pot. The maximum load is slowly re-applied and the data display is adjusted to read the maximum value using the gain pot. The load is the again slowly decreased to zero and this process is repeated until close agreement is reached at zero and maximum load. When a stable zero and maximum load condition is reached, the linearity can be checked by applying the load in a series of increments say 10, 25 and 75 percent of maximum and up to the maximum load itself.

A.3.0.5 1. - An alternative method involves the removal of the piston from the triaxial cell. The piston and load cell are then placed in a special ranging rig which makes the use of a steel block unnecessary. All other calibration operations are the same in both cases.

A3.0.6 CALIBRATION

If either the zero or gain pot "clicks" when being adjusted, this indicates that it has been adjusted beyond its range. In this case double check that the zero has been correctly adjusted, remember that there is a coarse and fine zero pot on the majority of WFE systems. If this does not solve the problem, the range factor on the channel needs to be altered these have two or more positions sometimes indicated by a switch A/B on the older WF17135/17150 Systems. In the WF18000 series and WF18005 series range selection is by an internal sliding switch. Please refer to the relevant operating manual. In the case of some simple non-WFE readout systems range adjustment is not provided and the inability to scale or range a load cell would indicate that the unit was not intended for use with this type of device.

Users of the Autotech Mk2 do not have screw adjustable potentiometers. The calibration is automatic, users of Mk2 AUTOTECHS should refer to the Autotech Instruction Manual. CLISP users will find this manual included in Appendix A.

A.3.0.7 If a load cell will not hold its maximum value and decreases in a continuous manner without adjustment: this indicates a failure of the strain gauging and the matter should be referred to WFE for investigation.

A.3.0.8 **RESOLUTION**

Some WF electronic measuring systems have nominal 16 bit resolution with accuracy of 1 in 20,000 available. The output from the WF17100 Series load cells with a capacity of 256kN cannot be scaled in Newtons. We suggest therefore that load cells are calibrated in kilograms force.

A.3.0.9 **REMOVAL OF THE TRIAXIAL CELL RAM FROM THE LOAD CELL**

The Triaxial cell ram (piston) should only be removed when absolutely necessary.

1. Carefully remove the grub screw from the "top hat" on the top of the RAM. Now carefully pull the RAM into the body of the triaxial cell taking care not to trap the electric cable.

2. A set of spanner flats are provided at the top of the load cell. Use a spanner to hold these rigid. Now carefully unscrew the RAM. **DO NOT APPLY ANY TORQUE TO THE SPANNER FLATS (AND HENCE TO THE LOAD CELL). YOU MUST TAKE GREAT CARE NOT TO TRAP OR ENTANGLE THE ELECTRICAL CABLE.** Proceed slowly, failure to observe these precautions will result in the electrical cable being severed from the load cell.

3. When fitting the load cell to another RAM or piston follow these instructions in the reverse order.

A.3.1.0 **DO'S AND DONT'S**

1. Do NOT allow the load cell to impact on the triaxial cell top, check that a circlip or other suitable device is fitted to the triaxial piston.

2. Always handle the load cell carefully, They are delicate scientific instruments.

3. NEVER allow the maximum load to be exceeded intentionally.

4. Do NOT attempt to dismantle the load cell.

5. Do keep the load cell and triaxial cell clean.

6. Do apply light machine oil sparingly to the triaxial cell piston, NEVER allow the piston to run dry. Clean the piston periodically.

7. Do take care with the electric cable emerging from the piston, do NOT allow them to become crushed by the dial gauge arm.

A3.1.1 TECHNICAL SPECIFICATION

SUBMERSIBLE LOAD CELL TYPE 17100 SERIES

Load Ranges	:	5, 10, 30 kN
Overload Capacity	:	200%
Rated output	:	2mV/V
Excitation Voltage	:	10VDC/15 VDC max
Non-Linearity	:	+/- 0.5% FS max
Hysteresis	:	0.5% FS max
Deflection	:	0.05mm
Max side force	:	50% FS
Input resistance	:	385 ohms
Output resistance	:	350 ohms
Compensated temperature range	:	0 degree to + 5- degree C
Thermal Zero Shift	:	0.02% FS/ degree C max
Thermal Sensitivity Shift	:	0.01% FS/ degree C max
Environmental pressure range	:	70 Bar max

Chapter 3

The WF volume change apparatus (WF17044/SN:107584-7)

3.1 Introduction

Due to lack of space inside the WF11001 triaxial cell, the volume change of the specimen is measured by a WF automatic volume change apparatus. The WF17044 automatic volume change apparatus allows for two different methods of measuring diaphragm displacement. The WF17044 is the most popular version. The apparatus has a piston area of $40.97cm^2$ and a distance stroke of 25mm. The capacity of the standard unit is 100ml, while the overall dimensions of the apparatus are $220 \times 170 \times 350$mm, weighting up to 8kgr. The apparatus consists of two chambers, which may sustain up to 1700kPa internal pore water pressure. The apparatus has two on-off valves. A "Bypass" and "Volume Change" valve and a "Flow up" and "Flow down" valve. The first valve allows water bypass the apparatus (when in saturation) or measure the volume of the water expelled or sucked by the specimen (during the consolidation or drained compression/extension) while the second one selects whether water coming in or out of the specimen will be sent to the upper or lower chamber of the volume change apparatus. The switching between the upper and lower chamber allows for infinite specimen volume change.

The apparatus utilises an external measuring medium, either a linear strain transducer or digital dial gauge. The linear strain transducer is mounted by a bracket, which holds the transducer in place and monitors the vertical movement of the piston of the apparatus. The LSC-HS25-9016 linear displacement transducer is utilised for this reason.

Figure 3.1: Wykeham Farrance volume change apparatus (photo taken from WF web site)

3.2 Installation

The back pressure line from the triaxial set-up should be connected to the right hand side of the reversing control module box, when viewed from the front. The left hand side connection on the control module box should be connected to the back pressure valve situated in the base of the triaxial cell.

The linear strain transducer or digital dial gauge indicator should be mounted using the appropriate bracket so that its lower spindle end rests against the moving anvil protruding from the side of the volume change cell.

The unit must be slowly filled using de-aired water by setting the left hand valve on the module, to the "Volume Change" position, as marked, and the lefthand valve to the "Flow up" position. Any entrapped air can then be bled from the unit by releasing the bleed cell valve located in the centre of the top of the cell chamber, as the de-aired water is fed into the cell. When water exudes from the bleed valve in the upper plate of the cell, tighten the screw to seal the upper chamber. It is then necessary to repeat the procedure from the lower chamber; the apparatus must be lifted off the reversing control box and inverted to remove the air. It will be necessary to reverse the water flow direction of "Flow down" using the flow valve, in order to fill both sides of the apparatus.

After removing the air, it is advisable to leave the apparatus overnight, or at least eight hours, with an internal pressure of approximately 700kPa.

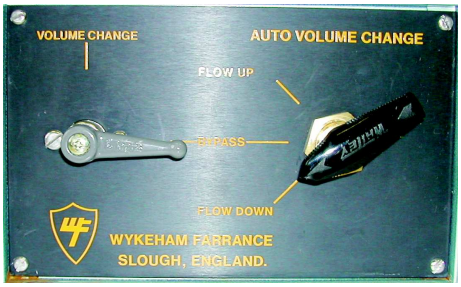


Figure 3.2: Wykeham Farrance volume change apparatus front panel, WF17044/SN:107584-7

This will allow any remaining trapped air to be absorbed into the solution. After this period, the apparatus should be carefully flushed out using new de-aired water, and thus displacing the aerated water. This flushing procedure must be carried out in both upper and lower chambers. It may be necessary to repeat this procedure once more, if any signs of air pockets occur during the first two days of operation.

3.3 Control Module Valve Positions

The reversing control module WF17042, which forms the base of the WF 17044, has the following controls and operating positions. These are two valves. The one on the left hand side of the box which has two positions: “Volume Change” and “Bypass” (see Figure 3.2). The other valve is situated on the righthand side of the box and has two positions: “Flow up” and “Flow down”. In order to bypass the automatic volume change apparatus, the lefthand side valve must be in the “Bypass” position, which will allow the water to flow directly through the triaxial cell without going through the volume change apparatus. To measure the actual volume change, the lefthand side valve must be set to the “Volume Change” position and the righthand side either to “Flow up” or “Flow down” positions. If during a test the apparatus is nearing its maximum volume change (100ml), the range of the apparatus can be increased by changing the flow direction using the righthand side valve.

3.4 Calibration

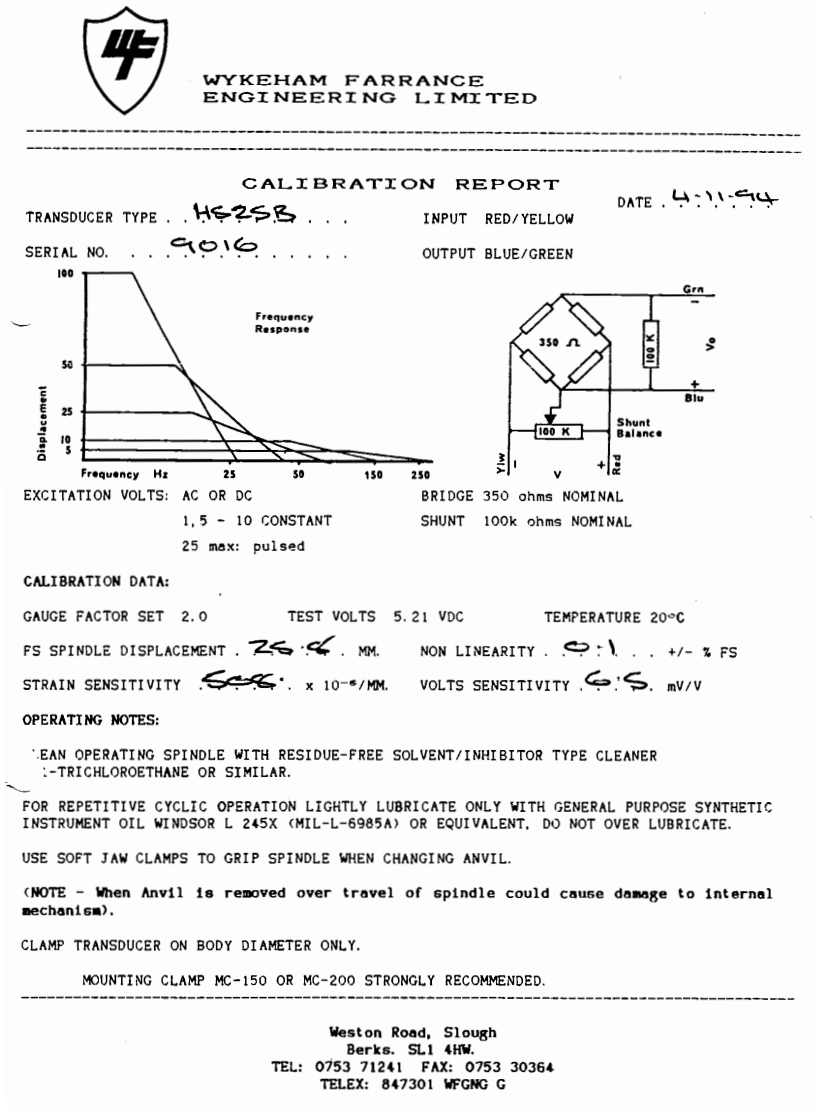
The WF17044 is easily calibrated, whether using the linear strain transducer or the digital dial gauge. Both devices measure from zero to full scale electrically and do not have a centre zero point. Thus the user can calibrate the device from zero to 100ml in engineering units. The transducer and

Operator	GIO	GIO
Place	GeoLab	GeoLab
Date	2004-05-25	2004-06-15
Time	11:25	13:10
Maximum spindle	-	25.8mm
Calibration constant	0.394mm/mV	0.396mm/mV
Linearity	99.9997%	99.9997%
Excitation voltage	10.00Volts	10.11Volts
Voltage Sensitivity	6.34mV/V	6.45mV/V
Sampling rate	-	1.000samples/sec
Temperature	-	-
Humidity	-	-

Table 3.1: LSC-HS25-9016 Calibration Table

the dial gauge should be connected to the appropriate readout device which should be switched on at least 12 hours before attempting the calibration.

The LSC-HS25-9016 used as the displacement gauge of the apparatus has a maximum spindle of 25.8mm and its volt sensitivity (5.21V excitation voltage) is 6.5mV/V (Calibration 1994-11-04, WF). Figures 3.3, 3.4 and 3.5 show the reference manual and calibration sheets of the above mentioned displacement transducer. Table 3.1 summarises the calibration constants. The wiring connection of the transducer consists of a shielded four-cable wire, which ends to a 5 pin socket plug (240^0). The wiring connection of the displacement transducer follows the below mentioned cabling: excitation voltage + (red), excitation voltage − (yellow), output voltage + (green), output voltage − (blue) and ground (shield).



WYKEHAM FARRANCE
ENGINEERING LIMITED

CALIBRATION REPORT

DATE . 4-11-94

TRANSDUCER TYPE . . HS25B . . . INPUT RED/YELLOW

SERIAL NO. . . . 9016 . . . . . OUTPUT BLUE/GREEN

EXCITATION VOLTS: AC OR DC
1,5 - 10 CONSTANT
25 max: pulsed

BRIDGE 350 ohms NOMINAL
SHUNT 100k ohms NOMINAL

CALIBRATION DATA:

GAUGE FACTOR SET 2.0 TEST VOLTS 5.21 VDC TEMPERATURE 20°C

FS SPINDLE DISPLACEMENT . 25.4 . MM. NON LINEARITY . 0.1 . . +/- % FS

STRAIN SENSITIVITY . 5446 . x 10^{-6}/MM. VOLTS SENSITIVITY . 6.5 . mV/V

OPERATING NOTES:

EAN OPERATING SPINDLE WITH RESIDUE-FREE SOLVENT/INHIBITOR TYPE CLEANER
:-TRICHLOROETHANE OR SIMILAR.

FOR REPETITIVE CYCLIC OPERATION LIGHTLY LUBRICATE ONLY WITH GENERAL PURPOSE SYNTHETIC INSTRUMENT OIL WINDSOR L 245X (MIL-L-6985A) OR EQUIVALENT. DO NOT OVER LUBRICATE.

USE SOFT JAW CLAMPS TO GRIP SPINDLE WHEN CHANGING ANVIL.

(NOTE - When Anvil is removed over travel of spindle could cause damage to internal mechanism).

CLAMP TRANSDUCER ON BODY DIAMETER ONLY.

MOUNTING CLAMP MC-150 OR MC-200 STRONGLY RECOMMENDED.

Weston Road, Slough
Berks. SL1 4HW.
TEL: 0753 71241 FAX: 0753 30364
TELEX: 847301 WFGNG G

Figure 3.3: Wykeham Farrance volume change apparatus displacement transducer reference manual, LSC-HS25-9016

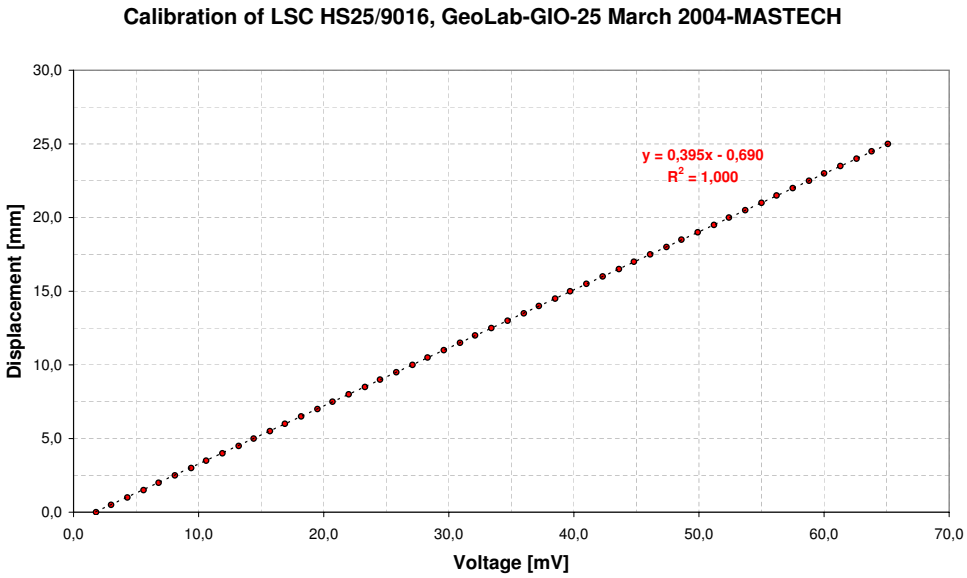


Figure 3.4: Wykeham Farrance volume change apparatus displacement transducer calibration, 2004-05-25, LSC-HS25-9016

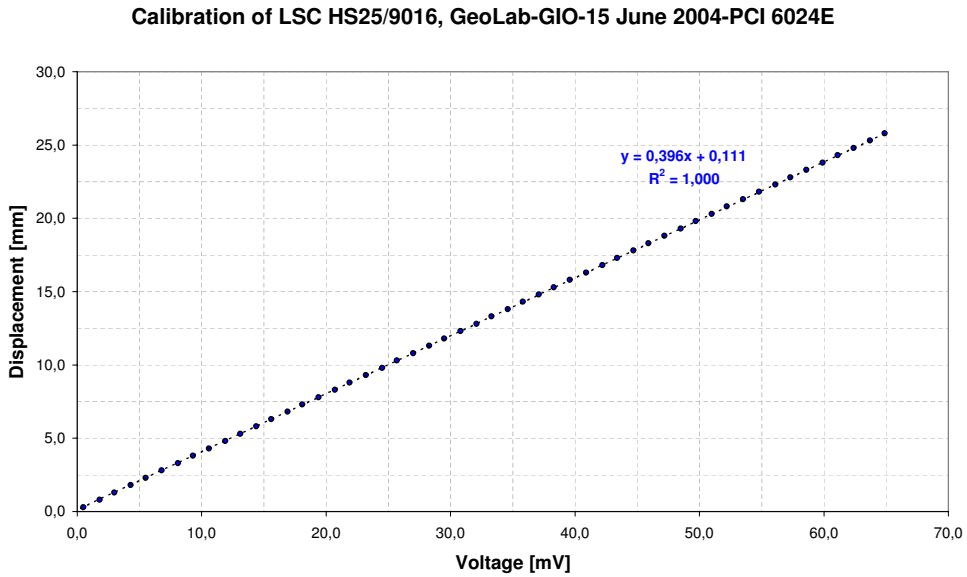


Figure 3.5: Wykeham Farrance volume change apparatus displacement transducer calibration, 2004-06-15, LSC-HS25-9016

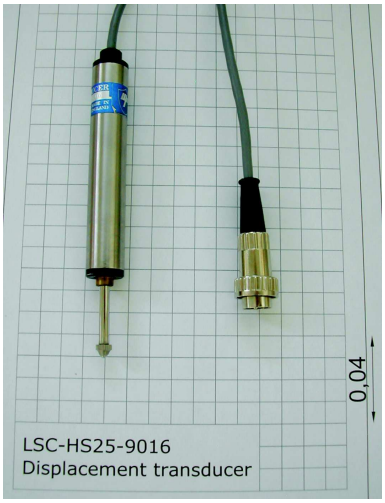


Figure 3.6: Wykeham Farrance volume change apparatus displacement transducer, LSC-HS25-9016

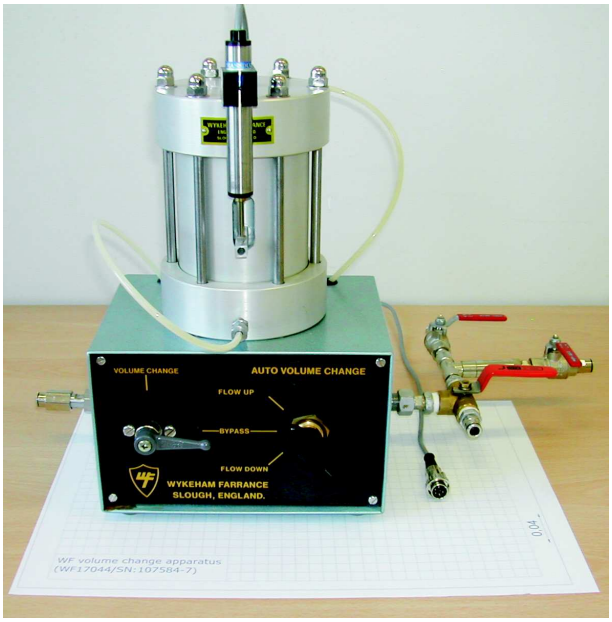
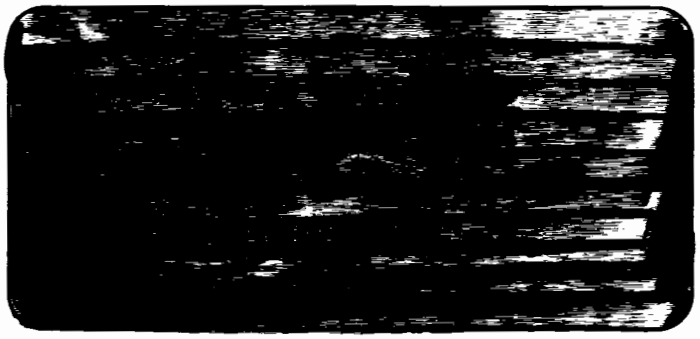


Figure 3.7: Wykeham Farrance volume change apparatus, WF17044/SN:107584-7

Wykeham Farrance international



Serial No

Wykeham Farrance International Limited
Weston Road
Trading Estate
Slough
Berks, SL1 4HW
England

Telephone 01753 571241
Telefax 01753 811313
Telex 847301 WFENG G
Email 101333,1232@compuserve.com

Contents

INTRODUCTION 3
INSPECTION *3*
SPECIFICATION 3
INSTALLATION OF WF17044 3
CONTROL MODULE VALVE POSITIONS 4
CALIBRATION 4
WF17043 AUTOMATIC VOLUME CHANGE 5

INTRODUCTION

The WF17043 and WF17044 automatic volume change apparatus from Wykeham Farrance allows for [redacted] methods of measuring diaphragm displacement. The WF17044 is the most popular version, this is described first.
The WF17043 utilises an external measuring medium, either a [redacted] transducer or a digital dial gauge.
The linear strain transducer has an [redacted] suitable for any data logging device which has an A to D converter, working on a signal input [redacted].
The digital dial gauge has digital output, suitable for use with a data logging device which requires digital input. (Refer to Wykeham Farrance catalogue).

WF17043 Automatic volume change unit has an operating capacity o[redacted] with an accuracy of at le[redacted]. When a greater volume than 100 ml is required, it is necessary to incorporate the WF17043 with a WF17042 [redacted] valve [redacted]. This assembly is known as the WF17044.

INSPECTION

Your WF17043/WF17044 automatic volume change was thoroughly inspected before it was shipped and should be ready to operate as soon as you have completed the setup procedure. Notify Wykeham Farrance or your local agent and file a claim with any carriers involved if you find any damage to the machine.

SPECIFICATION

[redacted]	[redacted] cm²
Distance of stroke	[redacted]
Capacity of standard unit	[redacted] ml
Overall height of WF17043**	230 mm
Overall height of WF17044**	350 mm
Overall diameter of WF17043**	130 mm
Overall dimensions of WF17044**	220 x 170 mm
Weight of WF17043**	5 kg
Weight of WF17044**	8 kg

** These are without a transducer and bracket.

INSTALLATION OF WF17044

[redacted] back pressure line from the triaxial set-up should be connected [redacted] right hand side of the reversing control module [redacted] from the front. The left hand side connection on the control module box should be connected to t[redacted] valve situated in the base of the triaxial cell.

The linear strain transducer or digital dial gauge indicator should be mounted using the appropriate bracket so that its [redacted] end rests against the moving anvil protruding [redacted] side of the volume change cell.

The unit must now b[redacted] filled using de-aired water by setting t[redacted] valve on the module, to the VOLUME [redacted] as marked, and the righthand v[redacted] to the FLOW UP position. Any entrapped air can then [redacted] from the unit by releasing the bleed cell valve located in t[redacted] top of the cell chamber, as the de-aired water is fed into the cell. When water exudes from the bleed valve in the upper plate of the cell, [redacted] screw to seal the upper [redacted]. It is then necessary to repeat the procedure for the lower chamber; the apparatus must b[redacted] tapping [redacted] and [redacted] to remove the air. It will be nec[redacted] to reverse the water flow direction of FLOW DOWN using [redacted], in order to fill both sides of the apparatus.

After removing the air, it is advisable to leave the [redacted] overnight, or for at least eight hours, with an [redacted] pressure [redacted] 200 kPa. This will allow any remaining trapped air to be absorbed into the solution. After this period, the apparatus should be car[redacted] flushed out using new de-aired water, and thus displacing the aerated water. This flushing procedure must be carried out in [redacted] upper and lower chambers. It may be necessary to repeat this procedure once more, if any signs of air pockets occur during the first two days of operation.

CONTROL MODULE VALVE POSITIONS

The reversing control module WF17042 which forms the base of the WF17044, has the following controls and operating positions.

There are two valves:

The one on the left hand side of the box which has two positions:

Volume change and **Bypass.**

The other valve is situated on the righthand side of the box and has three positions:

Flow down

Bypass

Flow up

In order to bypass the automatic volume change apparatus both valves must be in the Bypass position which will then allow the wate[redacted] directly through the triaxial cell without going through the volume change apparatus.

To measure the actual volume change the lefthand side valve must be set to the Volume Change position and the righthand side to either the Flow Up or Flow Down positions.

If during a test the apparatus is r[redacted] its maximum volume change (100 cc), the range of the apparatus can be increased by changing the flow direction using the righthand side valve. If used in this manner certain precautions are needed when calibrating the apparatus which are explained later in this manual.

CALIBRATION

The WF17044 is easily calibrated, whether using the linear strain transducer or the digital dial gauge. Both devices measure from zero to full scale electrically and do not have a centre zero point. Thus the user can calibrate the device from zero to 100 ml in engineering units (cc).

The transducer and digital dial gauge should be connected to the appropriate readout device which should be switched on for at least [redacted] before attempting calibration.

Allow water to flow into the volume change unit so that it moves the transducer spindle to its downwards maximum travel point. The digital displacement on the readout device (or the digital dial gauge), must then be adjusted to read zero.

Reverse the water flow into the volume change apparatus using the flow valve until the maximum upward movement has been achieved. The amount of water flowing into the volume change unit during this process should be measured accurately either by allowing the flowing out water to collect in a measuring cylinder or a pre-weighed beaker. Knowing the original weight of the beaker, the weight of displaced water can be accurately determined and thereby the volume. As an alternative to this, a precision burette could be used to measure the displaced water. When this actual volume has been determined, the dial gauge reading should be adjusted to show the volume displaced and/or the display on the readout device should be adjusted to the same volume. Because of the need for accuracy this calibration procedure should be carried o[redacted] until an acceptable agreement between the measured volumes and the digital displays has been achieved.

Please note that you should attempt to calibrate in one direction only.

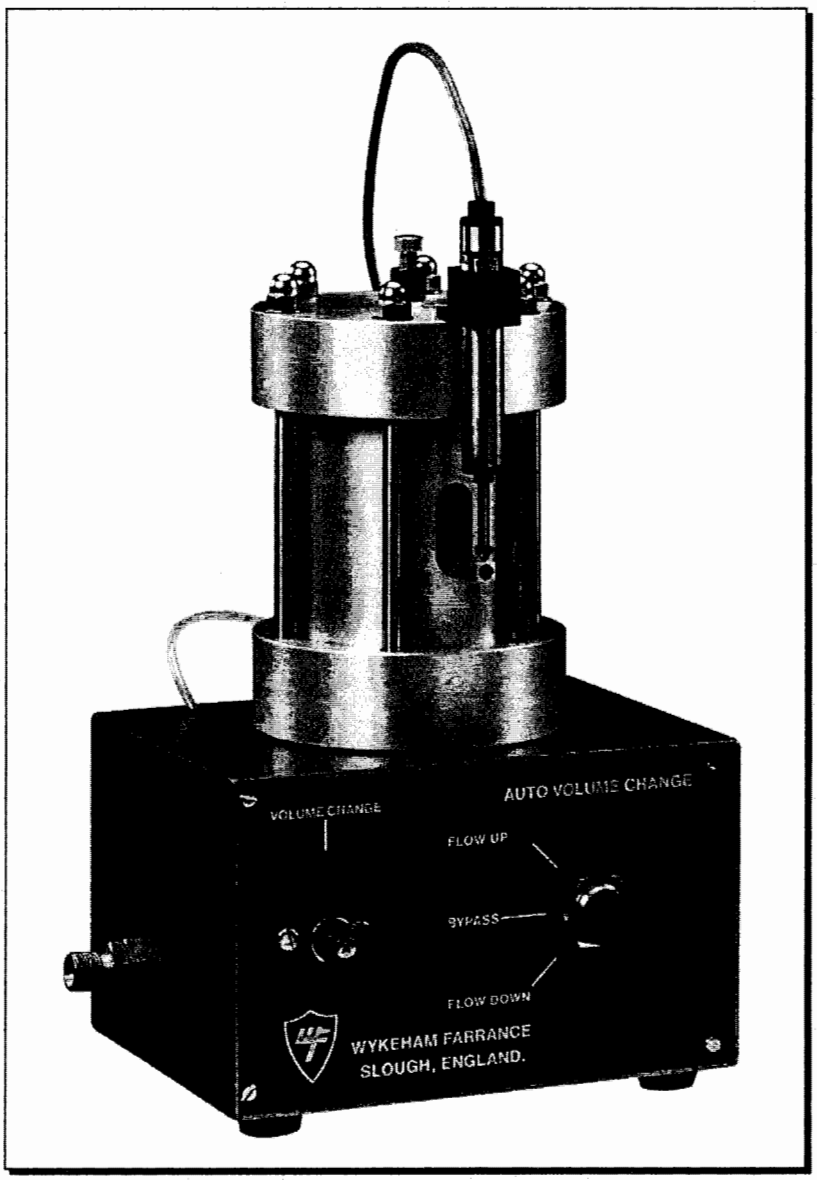
If you wish to use the volume change apparatus in both directions during a test, you must check [redacted] the calibrated readings in the original direction then use correction factors (if necessary) to overcome any small hysteresis in the transducer or dial gauge. Such procedures as shown above reduce any backlash in the apparatus to a minimum for small volume changes or research level work.

WF17043 AUTOMATIC VOLUME CHANGE

When using the automatic volume change device without a reversing module which must be connected to the users own valve or plumbing system, the unit includes a length of tubing for this purpose. The unit must then be reversed using the existing system of valves plumbed into the users system. It is because this approach can result in a large and complex pipework network, that we supply the control module as an optional extra.

If the unit is used directly in your pressure line without any provision for reversing flow, it is necessary to apply a second pressure in the opposite direction to move the internal diaphragm back to it original set rate position.

Wykeham Farrance
international



- **High Accuracy >±0.05ml**
- **Limitless Capacity**
- **Can be used with a digital dial gauge or transducer**

Automatic Volume Change Apparatus

The WFi automatic volume change apparatus is a 100cc capacity unit, which allows the accurate determination of volume change in a soil sample. It can also be used to measure permeability.

A Total Solution Provider

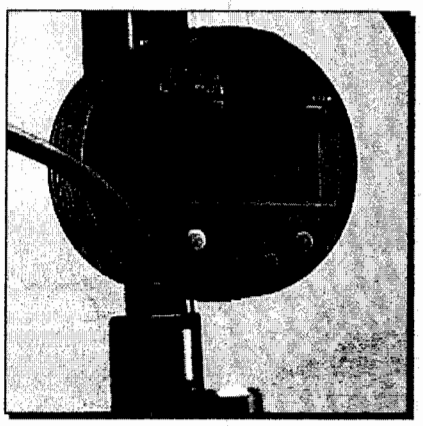
Technical Specification

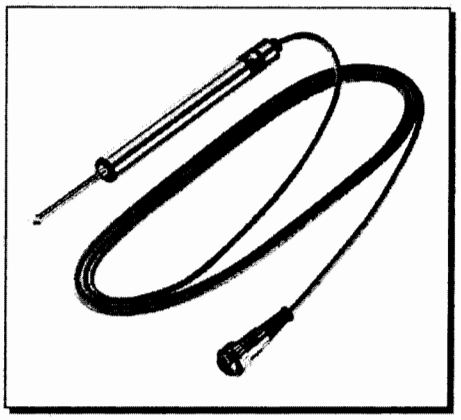
The automatic volume change apparatus consists of a calibrated chamber of known volume and a piston machined to tight tolerances, to give a precise measurement of the changing volume within the cylinder. As the piston moves an external measuring device, either an electronic dial gauge or an LVDT, either records or transmits the change in volume to a data logger.

If the change in volume exceeds 100cc then a changeover valve allows the internal piston to move in the opposite direction.

This can be repeated until volume change has completed.

Similarly large volumes of water can be measured during permeability testing.





Specification	
Capacity	Initially 100cc
Accuracy	>±0.05ml
Nett weight	7kg

Ordering Information	Part No.
Volume Change Apparatus 100cc capacity, complete with change over valves.	17044
Linear strain transducer, 25mm travel	17015
Bracket to fit linear strain transducer to automatic volume change unit.	17051
Digital Dial Gauge, 25mm travel with liquid crystal display.	18037
Extension shaft for digital dial gauge to make contact on measuring anvil	18045

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Wykeham Farrance International
Weston Road
Slough
England
SL1 4HW

Tel: +44 1753 571241
Fax: +44 1753 811313
Email: sales@wfi.co.uk

Chapter 4

The Data Acquisition System (WF-GeoDaq)

During a common triaxial test the eight (8) transducers (the axial force applied to the specimen, measured by an external (DBBSE-A2242-50kN) and an internal/submersible load cell (STALC3-24937-50kN), the axial displacement of the top cap of the specimen, measured by a LVDT (LSC-HS50-9021), the volume change of the specimen, measured by a WF automatic volume change apparatus (WF17044, LSC-HS25-9016), the cell pressure measured by two pressure transducers (Port1-RS Type 249-S086219 and Port3-2200AGB1001A2UA003) and pore pressure measured at the pedestal (Port2-2200AGB1001A2UA003) and top cap (Port4-RS Type 249-T023096)) are monitored by a data acquisition system (DAQ). The WF-GeoDaq consists of the a terminal box, where all transducers are plugged in, an analog/digital input output card installed in a personal computer and a data acquisition program, which manages the registries.

In the following, a short description of the three main parts of the WF-GeoDaq will be presented.

4.1 The terminal box

The terminal box can be considered as a robust and of practical use node between the transducers and the analog/digital input/output card, installed in the computer. The main purpose of the terminal box is twofold. On the one hand it serves as a board, where the cable plugs of the transducers are connected with their respective panel sockets, while, on the other hand it is used to provide the excitation voltage and receive the output voltage from the transducers. In Figures 4.2 and 4.3 external and internal view of the terminal box are given, while the basic instructions for the mounting of the terminal box itself are shown in Figures 4.4 and 4.5.

A 5 pin 240^0 pole-type cable plug (circular "DIN" connector) is used for

Figure 4.1: The WF-GeoDaq System

Figure 4.2: External view of WF-GeoDaq terminal box

Figure 4.3: Internal view of WF-GeoDaq terminal box

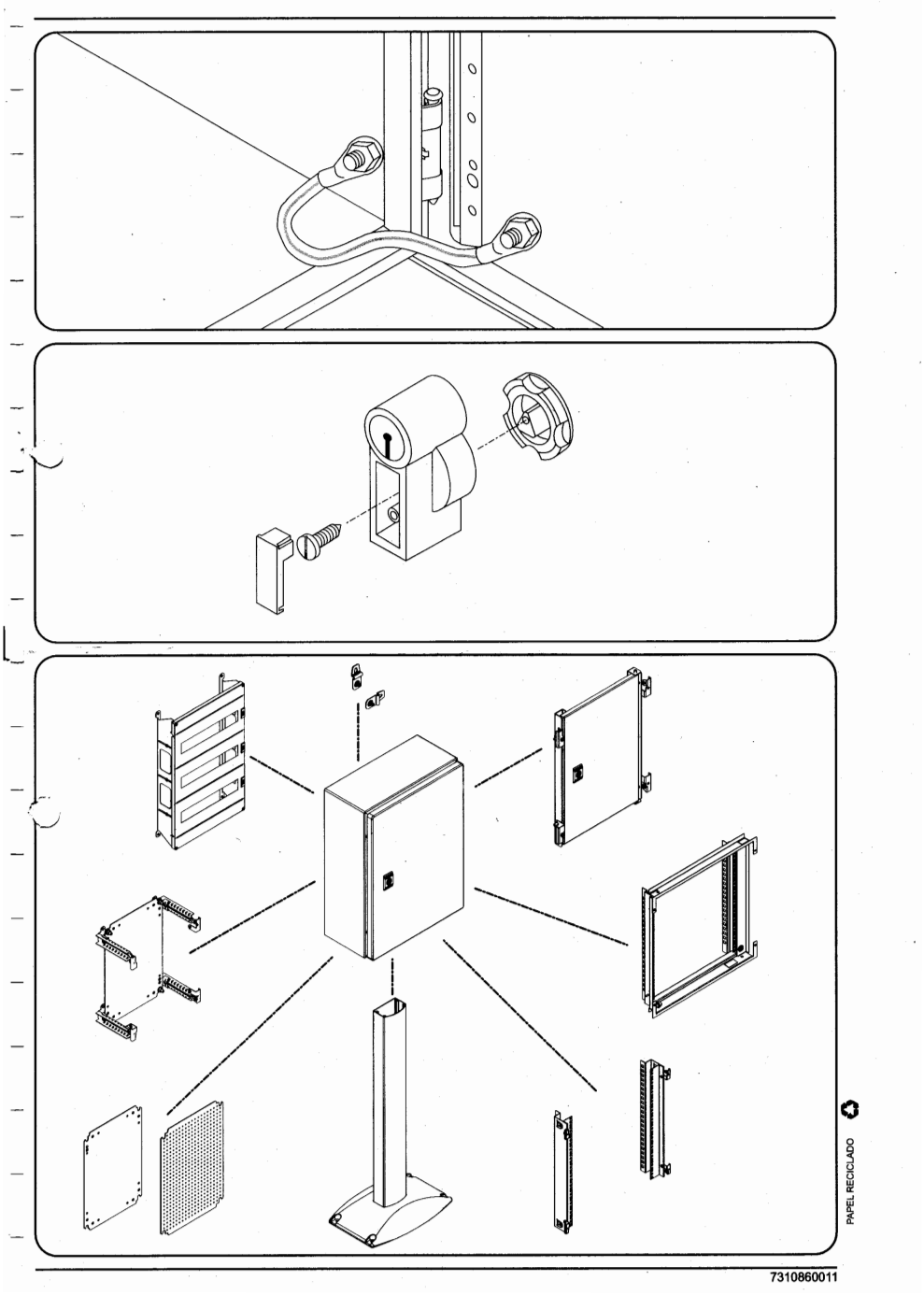


Figure 4.4: Instructions for mounting the terminal box (1)

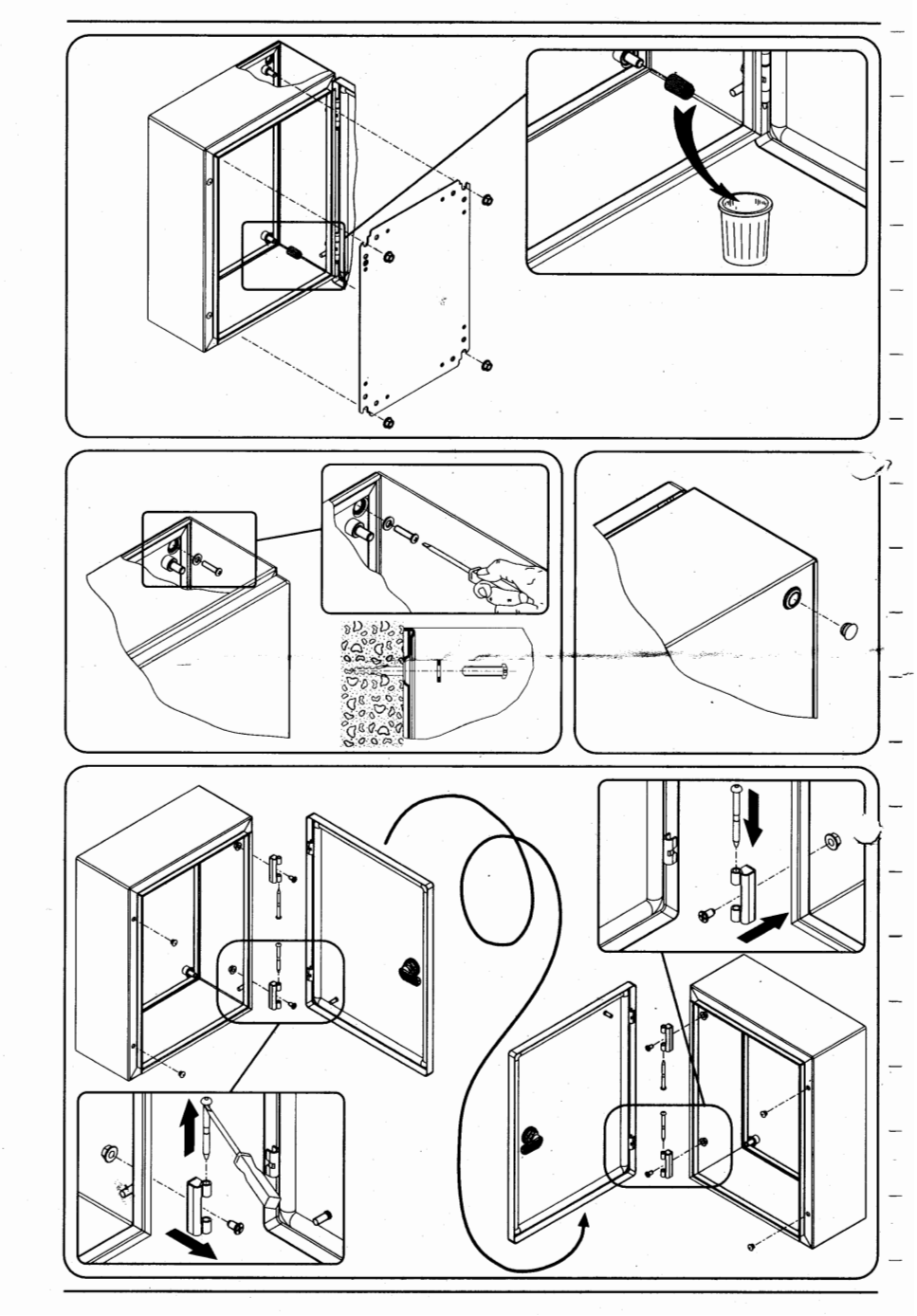


Figure 4.5: Instructions for mounting the terminal box (2)

Hinweis: DE

Dieses Heft enthält allgemeine Informationen zu Ihrer neuen Stromversorgung und beschreibt zusammen mit dem Beiblatt „Technische Daten" die Installation und den Betrieb. **Bei Abweichungen haben die Angaben im Beiblatt „Technische Daten" stets Vorrang**, bei sprachlichen Widersprüchen gilt die deutsche Version. Bei Irrtümern und in Zweifelsfällen fragen Sie bitte bei uns oder Ihrem Lieferanten nach. Technische Änderungen sind vorbehalten.

Die deutsche Anleitung finden Sie ab ..... Seite 3
Die zugehörigen Abbildungen finden Sie ab .....Seite 1

Note: EN

This booklet contains general information on your new power supply unit and together with the "Technical data" sheet it describes the installation and operation. **In case of discrepancies, the data contained in the "Technical data" leaflet always takes priority** and in case of linguistic contradictions, the German version prevails. In case of error or doubt, please contact us or your supplier. Subject to technical changes without prior notice.

You will find the English instructions on ..... page 5
You will find the illustrations on .....page 1

Information: FR

Ce manuel contient des informations générales au sujet de votre nouvelle alimentation électrique et, en combinaison avec le supplément "Données Techniques", il en décrit l'installation et l'exploitation. **En cas de dérogations, les indications fournies dans le supplément "Données Techniques" feront foi** et la version allemande s'appliquera dans le cas de contradictions linguistiques. Veuillez-vous adresser à nos services ou à votre fournisseur en cas d'erreurs ou de doutes. Sous toutes réserves de modifications techniques.

Vous trouverez la version française à partir de la ..... page 7
Vous trouverez les graphiques correspondants à partir de la .....page 1

Nota: ES

Este folleto contiene información general acerca de su nuevo suministro de corriente y junto con el suplemento "Datos técnicos" describe el proceso de instalación y operación. **En caso de discrepancias tendrán prioridad las informaciones del suplemento "Datos técnicos"**. De existir contradicciones lingüísticas regirá la versión alemana. En caso de errores o dudas comuníquese con nosotros o diríjase a su proveedor. Se reserva el derecho a efectuar modificaciones técnicas.

Las indicaciones en español figuran a partir de la ..... página 9
Las figuras correspondientes se encuentran a partir de la ..... página 1

Nota: IT

Il presente manuale contiene informazioni di carattere generale per il Vostro nuovo alimentatore di corrente e descrive, unitamente al prospetto allegato "Dati Tecnici", l'installazione ed il funzionamento. **In caso di divergenze, si tenga sempre conto che sono i "Dati Tecnici" contenuti nell'allegato ad aver la precedenza e che,** in caso di contrasti, sarà sempre la versione tedesca a far testo. In presenza di errori e in caso di dubbio siete invitati a sottoporre direttamente a noi o ai Vostri fornitori i quesiti del caso. Ci riserviamo il diritto di apportare modifiche tecniche.

Le istruzioni in italiano sono riportate a partire da .....pagina 11
Le rispettive figure sono riportate a partire da ..... pagina 1

Aviso: PT

Esse manual contém instruções gerais sobre sua nova fonte de alimentação elétrica e, juntamente com o anexo "Dados técnicos", descreve a sua instalação e operação. **Em caso de divergências, prevalecem as informações do anexo "Dados técnicos".** Quando houver diferenças entre os idiomas, prevalece a versão em alemão. Em caso de erros e dúvidas, dirija-se a nós ou ao seu fornecedor. Reservamo-nos o direito de efetuar alterações técnicas.

As instruções em alemão são encontradas a partir da .....página 13
As ilustrações correspondentes encontram-se a partir da ..... página 1

PU-327.015.00-10D
US Patent No. D442. 923S
Rev.: 01/2003

PULS

MiniLine

DIN-Rail Power Supplies

DE	Deutsch	**Installation und Betrieb**
EN	English	**Installation and Operation**
FR	Français	**Installation et fonctionnement**
ES	Español	**Instalación y funcion amiento**
IT	Italiano	**Installazione e funzionamento**
PT	Português	**Instalação e operação**

PU-327.015.00-10D/01/2003

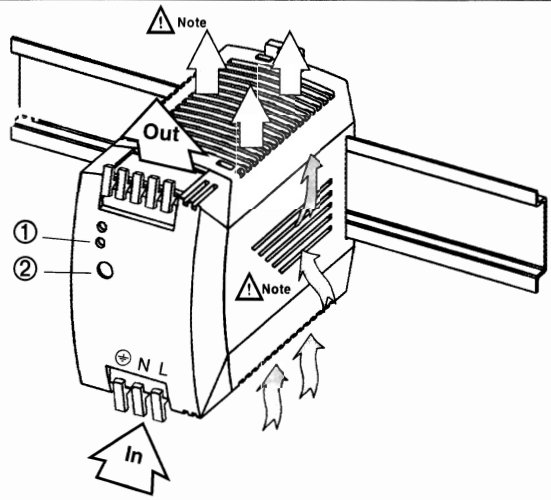


Fig. 1

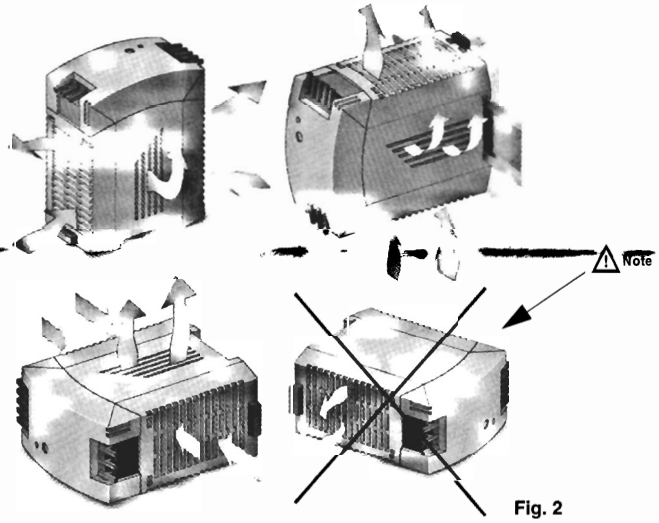


Fig. 2

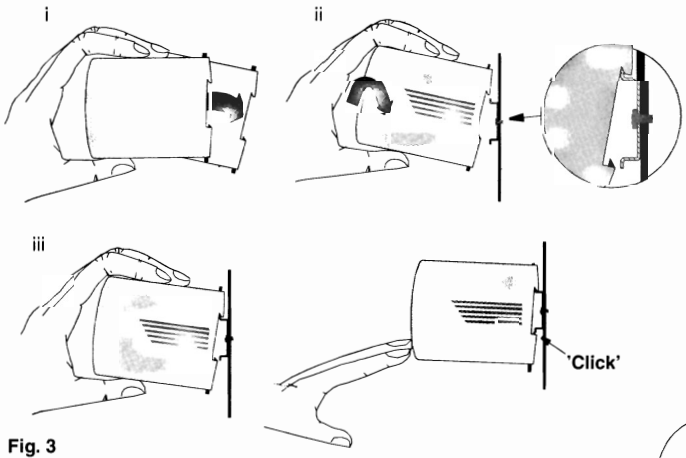
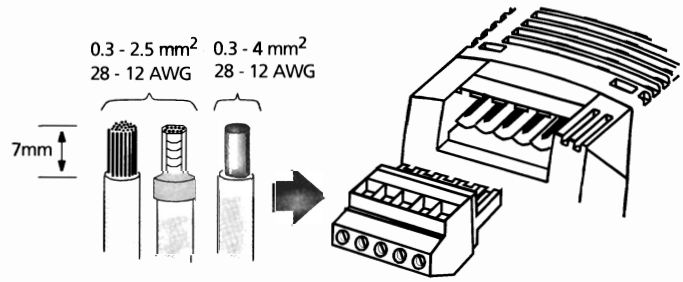
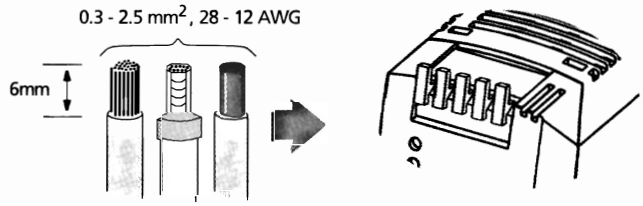


Fig. 3





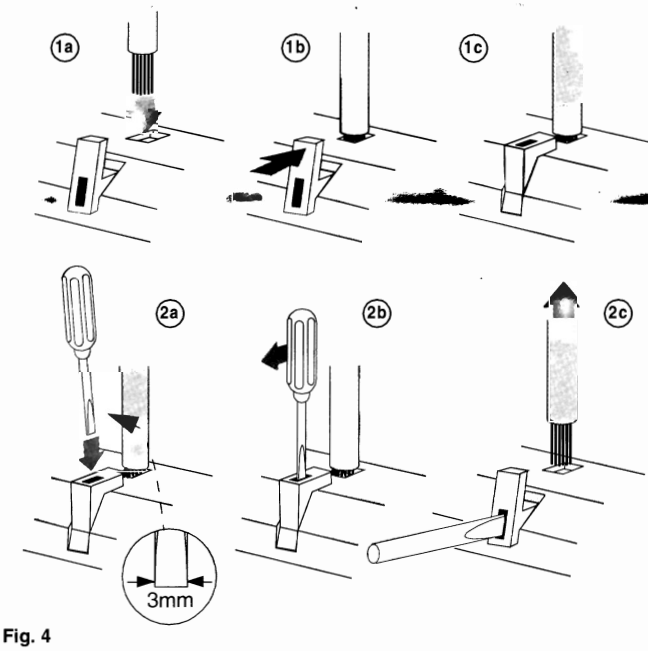


Fig. 4

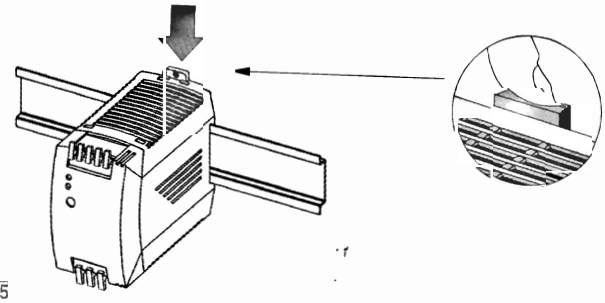


Fig. 5

PU-327.015.00-10D/01/2003

Notes on Safety (Fig. 1)

EN

Read instructions!	Before working with this unit: read these instructions carefully and completely. Make sure that you have understood all the information (ask colleagues)! Comply with notes on the unit!
Disconnect system from supply network	Before any installation, maintenance or modification work: Disconnect your system from the supply network. Ensure that it cannot be inadvertently re-connected!
Before start of operation: Ensure appropriate installation	Warning! Improper installation/operation may impair safety and result in operational difficulties or complete failure of the unit. The unit must be installed and put into service by appropriately qualified personnel. Compliance with the relevant regulations (DIN, VDE or specific national regulations) must be ensured. Before operation is begun the following conditions must be ensured, in particular: • Connection to mains supply in compliance with VDE0100 and EN50178. • With stranded wires: all strands must be secured in the terminal blocks (potential danger of short circuit). • Unit and power supply cables must be properly fused; A disconnecting device has to be provided for the end product to disengage unit and supply cables from supply mains if required. • The non-fused earth conductor must be connected to the ⏚ terminal (protection class 1). • All output lines must be rated for the power supply output current and must be connected with the correct polarity. • Sufficient air-cooling must be ensured.
In operation: No modifications!	As long as the unit is in operation: do not modify the installation! The same applies also to the secondary side. Risk of electric arcs and electric shock (could cause death)! **Only (dis)connect plug connectors when the power is off!**
Convection Cooling	**Do not cover** any ventilation holes! Fig. 1 ⚠ Note **Leave sufficient space** around the unit **for cooling**! For recommendation for spacing see supplementary sheet "Technical Data".
Warning: High voltage! Stored energy!	The unit contains unprotected conductors carrying a lethal high voltage, and components storing substantial amounts of energy. **Improper handling may result in an electric shock or serious burns!** • The unit must not be opened except by appropriately trained personnel! • Do not introduce any objects into the unit! • Do not open the unit for at least 5 minutes after it has been disconnected from the mains on all poles! • Keep away from fire and water!

Installation

EN

Admissible area of application	This unit is a primary switched-mode power supply unit **for use in panel-board installations or other building-in applications** where a suitable mechanical enclosure shall be provided to fulfill the requirements for shock-hazard protection and/or protection from hazardous energy levels as well as for fire protection. It must only be installed and put into service by appropriately qualified personnel.

Mounting

Mounting	Admissible **mounting positions:** see Fig. 2[b] (but: observe derating[a]). **Keep free ventilation holes, leave space for cooling!** Recommended respective distances: see supplementary sheet "Technical Data".
Attachment Snap on support rail (vgl. Fig. 2)	i) Tilt the unit slightly rearwards. ii) Fit the unit over top hat rail. iii) Slide it downward until it hits the stop. iv) Press against the bottom front side for locking. v) Shake the unit slightly to check the locking action

Front elements (Fig. 1)

Operation indicator (①)	Indicates whether the unit is working properly. Green LED is on in normal operation and goes out if overloaded.
Potentiometer[c] (②)	Setting the output voltage[a].

Connection / Internal fuse

Connection	• Data for permitted loads, cable cross-sections and stripping as well as for external fusing: see the enclosed leaflet "Technical Data", sub heading "Connection to Mains" or "Output" • Handling of the terminals: see Fig. 4 • Use only commercial cables designed for the indicated voltage and current values! • With flexible cables: make sure that all cable strands are secured in the terminal. • Suitable conductor terminal sleeves (ferrules) may be used. • Ensure proper polarity at output terminals!
Grounding	• **Do not operate without PE connection!** To comply with EMC and safety standards (CE mark, approvals), the unit must only be operated if the PE terminal (⏚) is connected to the non-fused earth conductor • Secondary side is not earthed; if necessary the ⊕ or ⊖ terminal can be earthed optionally.
Internal fuse	The internal input fuse protects the unit and must not be replaced by the user. In case of an internal defect, the unit must be returned to the manufacturer for safety reasons.

Removal

Removal Detaching from the support rail	**Before removal:** Switch mains power off and disconnect your system from the supply network. See Fig. 5: push the slider downwards (unlock). Gently lift lower front edge of the unit (tipping) and remove.

Recycling

♻	The unit contains elements which are suitable for recycling, and components which need special disposal. You are therefore requested to make sure that the unit will be recycled by the end of its service life.

Remarks:

a) See enclosed leaflet "Technical Data" sub heading "Connection to Mains" or "Output" for details.

b) unless there are other instructions either on the unit or in the enclosed leaflet "Technical Data"

c) Not available with all units

This is a general information leaflet for all units in the current range. With some units deviations from the instructions described here are possible, **therefore instructions in the "Technical data" leaflet enclosed always take priority.** In case of doubt the German version applies.

Fig. 1: V_{out} vs. I_{out} (min.)

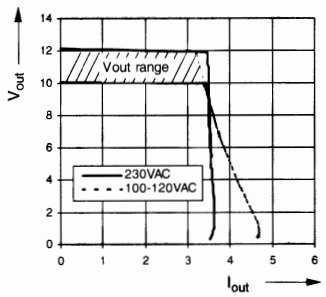
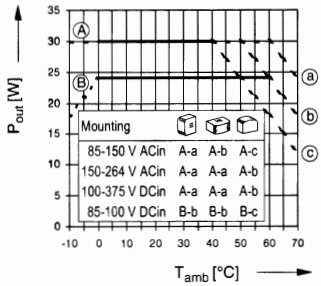


Fig. 2: Derating



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PULS GmbH
Arabellastraße 15
D-81925 München
Germany
Tel. (+49) (089) 9278-0
Fax (+49) (089) 9278-299
sales@puls-power.com
www.puls-power.com
Rev.: 01/2003

PU-322.012.02-10C

US Patent No. D442, 923S

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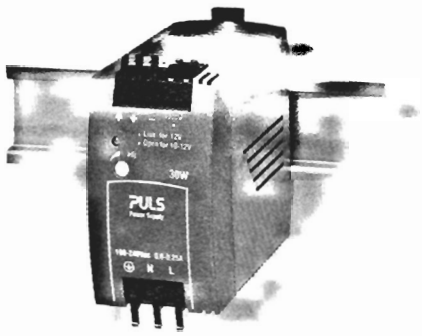


MiniLine

ML30.102

DE Deutsch
EN English
FR Français
ES Español
IT Italiano
PT Português

Technische Daten
Technical Data
Données Techniques
Datos Técnicos
Dati Tecnici
Dados Técnicos

ML30.102: Technische Daten

DE

Netzanschluß (AC_{in})

Eingangsspannung V_{in}

• Nennwert	100-240 V AC
Frequenz	47-63 Hz
• AC Dauerbetrieb	85-264 V AC
• DC Dauerbetrieb	85[e]-375 V DC

Eingangsstrom I_{in}

• Nennwert	< 0,6 A @100 V ACin < 0,25 A @ 240 V ACin
• Einschaltstrom I_{pk} / I^2t	17,5A/0,3A^2s (120Vin), 36A/1,2A^2s (240Vin)

(typ., T_U = 50°C, Kaltstart, Netz gem. EN 61000-3-3)

Powerfaktor (PFC):
Gerät erfüllt EN 61000-3-2

Externe Absicherung
- für Geräteschutz nicht erforderlich (interne Sicherung)
- nationale Vorschriften beachten

Anschlußleitungen[c]

• flexible Kabel	0,3-2,5 mm^2 (AWG=28-12)
• starre Kabel	0,3-4 mm^2 (AWG=28-12)
• Abisolieren am Kabelende	6 mm empfohlen

Größe, Gewicht

Breite w	45 mm
Höhe h	75 mm
Tiefe d	91 mm + DIN-Rail
Gewicht	250 g

Kühlung

Konvektionskühlung – Genügend Freiraum zur Kühlung lassen![c]
Bei ausreichender Konvektionsströmung sollte der Temperatur-Unterschied ΔT zwischen Luftein- und -austritt am Gehäuse nicht mehr als ca. 15K betragen. Empfohlener Freiraum an den Lüftungsöffnungen: mind. 25 mm

Normen, Zulassungen

Das Gerät erfüllt alle folgenden Normen:

EMV:
EN50081-1 und -2 (Störaussendung)
(EN 55011, EN 55022, Klasse B),
EN61000-6-2 und EN 55024 (Störfestigkeit),
VDE 0160/W2 (Transientenfest)

Sicherheit:
EN 60950, EN 60204-1, EN 50178,
IEC 60950, UL 60950, UL 508,
CAN/CSA-C22.2 No. 60950 (CUR)
CAN/CSA-C22.2 No. 14 (CUL)

CE-Kennzeichnung erfolgt nach EMV-Richtlinie und Niederspannungsrichtlinie.

Anmerkungen/Hinweise:
a) sofern am Gerät nicht anders angegeben; Geräteversand mit voreingestellter Brücke (12 V ±0.5%)
b) 200 kHz Bandbr., 50Ω-Messung (<2mV_{SS})
20 MHz Bandbr., 50Ω-Messung (<10mV_{SS})
c) siehe Beiblatt „Installation und Betrieb" für weitere Informationen
d) Bei Standard-Einbaulage (vgl. Bild rechts) und ACin; andere Bedingungen gemäß Fig. 2
e) Derating (Fig. 2) beachten

Ausgang (DC_{out})

Nennspannung V_{out}

• Einstellbereich, minimal	10-12 V [a]
• voreingestellt [a]	10 V ±0,5% (ohne Brücke), 12 V ±0,5% (mit Brücke)
• Regelgenauigkeit	stat. <1% @V_{out} 10V stat. <1,2% @V_{out} 12V dyn. ±2,5 % V_{out}
• Restwelligkeit (Ripple)/ Noise (Spikes)[b]	< 2 mV_{SS} < 10 mV_{SS}
Zul. Dauerbelastung I_{out}	bis zu 3 A (10 V), bis zu 2,5 A (12 V)

bei T_U=-10°C...+60°C, abhängig von Einbaulage, V_{in}, T_U; siehe Fig.1 und Fig. 2 für Details

• Strombegrenzung	typ. 3,2 A @ 100-120V AC, typ. 3,5 A @ 230V AC (vgl. Kennlinie Fig. 1)
• Verhalten bei Überlast/Kurzschluß	kein Abschalten, Gerät läuft weiter
• Derating	siehe Fig. 2

Kennlinienverlauf: siehe Fig. 1
Parallelschaltung: möglich; keine gleichmäßige Lastaufteilung

Anschlußleitungen[c]

• flexible Kabel	0,3-2,5 mm^2 (AWG=28-12)
• starre Kabel	0,3-4 mm^2 (AWG=28-12)
• Abisolieren am Kabelende	6 mm empfohlen

Umweltdaten

Umgebungstemperatur T_U gemessen 25 mm unter Lufteintritt ins Gehäuse

• Lagerung/ Transport	-25°C...+85°C
• Vollast [d]	-10°C...+60°C
• Derated [d]	+60°C...+70°C

Schutzart: IP20 (IEC60529),
Vor Feuchtigkeit (auch Betauung) schützen!

Sicherheit/Schutz

Sicherheitshinweise beachten!
Siehe Beiblatt „Installation und Betrieb"

Sicherheit und Schutz

• Überspannungsschutz (sekundärseit.)	✓, (V_{out}-Begrenzung bei max. 18 V)
• Überlastfest	✓
• Dauerkurzschlußfest	✓
• Leerlauffest	✓
• Übertemperaturschutz	–
• Rückeinspeise-festigkeit	max. 30 V
• Interne Eingangs-sicherung	T3A15/250V HBC (IEC127), Klemme L[c]
• Schutzklasse	I (EN 60950)
• Sicherheits-kleinspannung	SELV (EN 60950, VDE 0100 Part 410), PELV (EN 50178)

ML30.102: Technical Data

EN

Connection to Mains (AC_{in})

Input Voltage V_{in}

• Nominal	100-240 V AC
Frequency	47-63 Hz
• AC continuously	85-264 V AC
• DC continuously	85[e]-375 V DC

Input Current I_{in}

• Nominal	< 0.6 A @100 V ACin < 0.25 A @ 240 V ACin
• Inrush current I_{pk} / I^2t	17.5A/0.3A^2s (120Vin), 36A/1.2A^2s (240Vin)

(typ., T_{amb} = 50°C, cold start, mains acc. EN 61000-3-3)

Power factor (PFC):
Unit fulfills EN 61000-3-2

External Fusing
- for unit protection not necessary (internal fuse)
- observe national regulations

Connector cables[c]

• flexible cable	0,3-2,5 mm^2 (AWG=28-12)
• solid cable	0,3-4 mm^2 (AWG=28-12)
• stripping at cable end	6 mm recommended

Size, Weight

Width w	45 mm
Height h	75 mm
Depth d	91 mm + DIN-Rail
Weight	250 g

Cooling

Convection Cooling – Leave sufficient space around the unit for cooling![c]
With a sufficient convection air stream, the temperature difference ΔT between entering and exiting air at the housing surface should not exceed approx. 15K.
Recommended free space **at all sides** with ventilation holes: 25 mm each

Standards, Certifications

The unit fulfills all following standards:

EMC:
EN50081-1 and -2 (Emissions)
(EN 55011, EN 55022, Class B),
EN61000-6-2 and EN 55024 (Immunity)
VDE 0160/W2 (Transient protect.)

Safety:
EN 60950, EN 60204-1, EN 50178, IEC60950,
UL 60950, UL 508,
CAN/CSA-C22.2 No. 60950 (CUR)
CAN/CSA-C22.2 No. 14 (CUL)

CE-Marking in compliance with EMC directive and low-voltage directive.

Notes:
a) unless specified otherwise on the unit; unit is delivered with jumper preset (12 V ±0.5%)
b) 200 kHz bandwidth, 50Ω measurement (<2mV_{PP}); 20 MHz bandwidth, 50Ω measurement (<10mV_{pp})
c) See supplementary sheet „Installation and Operation" for further details
d) At standard mounting position (cf. figure at the right) and ACin; other conditions see Fig. 2.
e) Observe derating (Fig. 2)

Output (DC_{out})

Rated Voltage V_{out}

• Adjustment limits, min.	10-12 V [a]
• Preset[a]	10 V ±0.5% (without jumper), 12 V ±0,5% (with jumper)
Accuracy of regulation	stat. <1% @V_{out} 10V stat. <1.2% @V_{out} 12V dyn. ±2.5 % V_{out}
• Ripple/ Noise (Spikes)[b]	< 2 mV_{PP} < 10 mV_{PP}
Permissible Load I_{out}	up to 3 A (10 V), up to 2.5 A (12 V)

@ T_{amb}=-10°C...+60°C (45°C), depending on mounting position, V_{in}, T_{amb}; see Fig. 1 and Fig. 2 for details

• Current limitation	typ. 3.2 A @ 100-120V AC, typ. 3.5 A @ 230V AC (see curve in Fig. 1)
• Overload/Short circuit characteristic	Continuous operation without unit shutdown
• Derating	see Fig. 2

Characteristic curve: see Fig. 1

Parallel operation: possible; no equal load sharing

Connector cables[c]

• flexible cable	0,3-2,5 mm^2 (AWG=28-12)
• solid cable	0,3-4 mm^2 (AWG=28-12)
• stripping at cable end	6 mm recommended

Environmental Data

Ambient temperature T_{amb} measured at 25 mm under the air input in the housing

• Storage/Shipment	-25°C...+85°C
• Full nominal load[d]	-10°C...+60°C
• Derated[d]	+60°C...+70°C

Degree of protection: IP20 (IEC60529), Protect from moisture (and condensation)!

Safety/Protection

Read safety instructions!
See attached sheet „Installation and Operation"

Safety and protection

• Overvoltage protection (second. side)	✓ (V_{out} limitation at max. 18 V)
• Resistant to overload	✓
• Resistant to sustained short-circuit	✓
• Resistant to open-circuit	✓
• Overtemperature protect.	–
• Reverse power immunity	max. 30 V
• Internal input fuse	T3A15/250V HBC (IEC127), terminal L[c]
• Protection class	I (EN 60950)
• Extra low safety potential	SELV (EN 60950, VDE 0100 Part 410), PELV (EN 50178)

ML30.102: Données Techniques

FR

Raccord de réseau (AC_{in})

Tension d'entrée V_{in}

• Valeur nominale	100-240 V AC
• Fréquence	47-63 Hz
• AC, permanent	85-264 V AC
• DC, permanent	85[e]-375 V DC

Courant d'entrée I_{in}

• Valeur nominale	< 0,6A @100V ACin < 0,25A @240V ACin
• Courant de mise en route I_{pk} / I^2t	17,5A/0,3A^2s (120V), 36A/1,2A^2s (240V)

(typ., T_{amb} = 50°C, départ à froid, réseau selon EN 61000-3-3)

Facteur de puissance (PFC):
L'appareil répond à la norme EN 61000-3-2

Protection externe
- pour protection de l'appareil pas nécessaire (protection interne)
- observez des règlements nationaux

Conduites de raccordement[c]

• Câbles souples	0,3-2,5 mm^2 (AWG=28-12)
• Câbles rigides	0,3-4 mm^2 (AWG=28-12)
• Degainage en bout du câble	6 mm recommandé

Dimensions, Poids

Largeur w	45 mm
Hauteur h	75 mm
Profondeur d	91 mm + profilé
Poids	250 g

Refroidissement

Réfrigération de convection– Prévoir assez d'espace libre pour la refroidissement![c]
Le courant de convection étant suffisant, la difference de température ΔT entre l'air entrant et l'air sortant, mesurée au carter, ne devrait pas dépasser 15K environ.
Espace libre recommandé aux côtés ayant des baies d'aération: chaque 25mm

Normes, Autorisations

L'appareil répond aux normes suivantes:

CEM (compatibilité électromagnétique):
EN50081-1 et -2 (émission de perturbation)
(EN 55011, EN 55022, Classe B),
EN61000-6-2 et EN 55024 (résistance aux perturbation),
VDE 0160/W2 (résistance aux transitoires)

Sécurité:
EN 60950, EN 60204-1, EN 50178,
IEC 60950, UL 60950, UL 508,
CAN/CSA-C22.2 No. 60950 (CUR)
CAN/CSA-C22.2 No. 14 (CUL)

La caractérisation CE se fait selon la directive CEM et la directive de la tension basse.

Remarques:
a) dans la mesure où aucune avis contraire n'est indiqué sur l'appareil; l'appareil livré avec 'jumper' présélectionné (12 V ±0,5%)
b) 200 kHz largeur de bande, mesure 50Ω (<2mV_{pp}); 20 MHz largeur de bande, mesure 50Ω (<10mV_{pp})
c) pour des informations supplémentaires, voir la feuille annexe „Installation et fonctionnement"

Sortie (DC_{out})

Tension nominale V_{out}

• Plage d'ajustem. min.	10-12 V [a]
• Présélectionnée[a]	10 V ±0,5% (sans 'jumper'), 12 V ±0,5% (avec 'jumper')
• Précision du réglage	stat. <1 % @V_{out} 10V stat.<1,2% @V_{out}12V dyn. ± 2,5% V_{out}
• Ondulation residuelle/ Bruit (transitoires)[b]	< 2 mV_{PP} < 10 mV_{PP}
Charge autorisée I_{out}	jusqu'a 3 A (10 V), jusqu'a 2,5 A (12 V)

à T_{amb}=-10°C...+60°C, dépendant de la direction de montage, V_{in}, T_{amb}; voir Fig. 1 et Fig. 2 pour plus de détails

• Limitation de courant	typ. 3,2 A @ 100-120V AC, typ. 3,5 A @ 230V AC voir caractérist., Fig. 1)
• Comportement en cas de surcharge / court-circuit	pas d'arrêt. l'appareil continue de fonctionner
• Derating	voir Fig. 2

Déroulement de la caractéristique: voir Fig. 1

Montage en parallèle: possible; pas de répartition uniforme de la charge

Conduites de raccordement[c]

• Câbles souples	0,3-2,5 mm^2 (AWG=28-12)
• Câbles rigides	0,3-4 mm^2 (AWG=28-12)
• Degainage en bout du câble	6 mm recommandé

Données climatiques

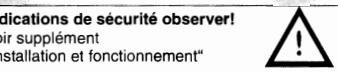
Température ambiante T_{amb}, mesurée à 25 mm en dessous de l'entrée d'air dans le carter

• Stockage/transport	-25°C...+85°C
• Pleine charge[d]	-10°C...+60°C
• Derated[d]	+60°C...+70°C

Type de protection: IP20 (IEC60529), Protéger contre l'humidité (et la rosée)!

Securité, Protection

Indications de sécurité observer!
Voir supplément „Installation et fonctionnement"



Securité/Protection:
protection/résistance

• contre la surtension (côté secondaire)	✓ (limitation de V_{out} à max. 18 V)
• contre la surcharge	✓
• aux court-circuits permanent	✓
• à la marche à vide	✓
• contre la surtemperature	–
• contre aliment. en retour	max. 30 V
• Fusible protect. d'entrée interne	T3A15/250V HBC (IEC127), borne L[c]
• Classe de protection	I (EN 60950)
• Tension basse de sécurité	SELV (EN 60950, VDE 0100 Part 410), PELV (EN 50178)

Remarques (Suite):
d) Condition: Installation en direction standard (voir illustration a droite) et ACin; pour des conditions differentes voir Fig. 2
e) Respecter derating (Fig. 2)

Figure 4.6: WF-GeoDaq terminal box spare parts

all transducers, while eight (8) panel sockets are firmly screwed on side of the terminal box. Looking from the lower part of the terminal box up to the upper part, the internal/submersible load cell (STALC3-24937-50kN, the external load cell (DBBSE-A2242-50kN), the axial displacement transducer (LSC-HS50-9021), the WF-Automatic Volume Change Apparatus (WF17044, LSC-HS25-9016), the cell pressure transducer (Port1-RS Type 249-S086219, the pore pressure transducer at the pedestal (Port2-2200AGB1001A2UA003), the cell pressure transducer (Port3-2200AGB1001 A2UA003) and the pore pressure transducer at the top cap (Port4-RS Type 249-T023096) are mounted.

Taking a closer look of the terminal box, an on-off switch, equipped with a 6A fuse, is used to fire up the eight transducers, and is found, for safety reasons, in the lower side of the terminal box. An AC/DC transformer is used to provide a stable DC (10Volts) as excitation voltage to the above mentioned transducers. It has a maximum power of 30Watts (3A in 10Volts or 2.5A in 12Volts).

The connection diagram of the 5 pin 240^0 pole-type cable plugs for all transducers is the same (for safety reasons), and is as follows: Looking from the right to the left (counterclockwise), the first pin of the cable plug is the excitation +, the second the excitation −, the third is the neutral or earth, where the shield of the cable is usually connected to, the fourth is the output −, while the fifth is the output +.

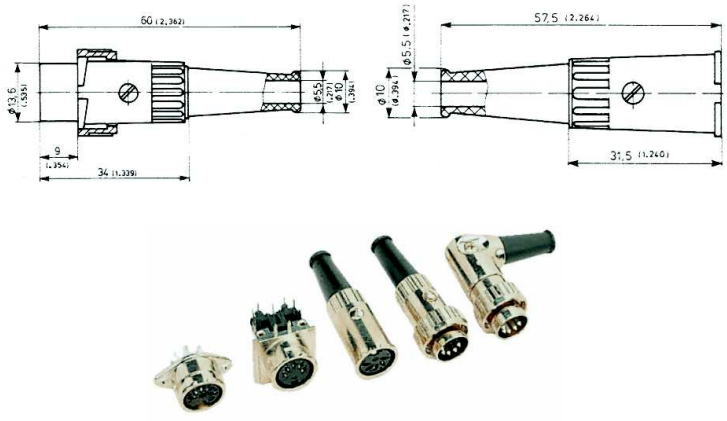


Figure 4.7: Typical 'DIN' 5 pin 240^0 pole-type cable plugs

In order to have a more robust connection between the transducers and the analog/digital input/output card, a CB-68LP connector board is also mounted inside the terminal box. A RC68-68 1m cable is used to connect the analog/digital input/output card with the connector board. In this way, the analog output signal from the transducers is transmitted to the card via a cable, allowing for quick removal of the transducers' cable plugs, in case of unplugging the transducers from the terminal box.

Finally, for quick removal of the terminal box components, the AC/DC transformer and the connector board are mounted on a chassis plate, firmly gripped by four bolts and nuts at its corners. Not to mention that the front door can be easily removed from its hinges, according to Figure 4.5.

4.2 The analog/digital input/outup card

An analog/digital input/output National Instruments© PCI-6024E card is installed in a personal computer. The card is installed in a PCI port on the motherboard and connected to the connector board, in the terminal box. The main function of the card is to convert the analog output of the transducers to digital signal, so it can be further processed by the personal computer. One of the most important features/specifications of such a card is the number of analog input channels and its scanning rate capability. The PCI-6024E card has 16 analog input channels. In case the input analog signal is single ended, then the response of 16 transducers can be read. Should the signal be differential, the number of analog channels is reduced to 8. Further specifications of the analog/digital input/output NI PCI 6024E card can be found in the attached card's manual.

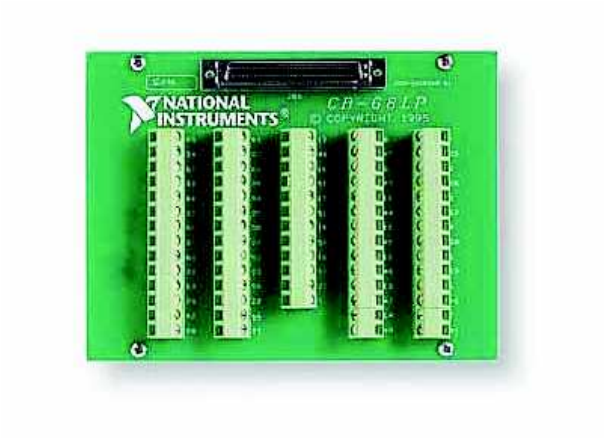


Figure 4.8: CB-68LP connector board

Figure 4.9: Analog/digital input/output data acquisition card (NI PCI-6024E)

NATIONAL INSTRUMENTS™

Certificate of Calibration

Board Information

Serial Number: C831B3
NI Part Number: 187570B-02
Description: PCI-6024E

Certificate Information

Certificate Number: 266156
Date Printed: 26-APR-2001
NI Part Number: 184632A-01

Calibration Date: 26-APR-2001
Calibration Interval: 12 Months
Calibration Due: 26-APR-2002

Ambient Temperature: 24 °C
Relative Humidity: 43 %

National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9002 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.

National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology or are derived from accepted values of natural physical constants.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.

For questions or comments, please contact National Instruments Technical Support.

Signed,

Domingo Salcido
Operations Manager

NATIONAL INSTRUMENTS
TYPE: R6868
MANUFACTURING P/N: 182482A-01
CATALOG NUMBER: 182482-01

09/08/00
321722C-01

National Instruments has been registered as compliant with the ISO 9002-1994 standard.

Counter/Timer Accessories and Cables

SCB-68 Shielded I/O Connector Block (See Figure 3)

Shielded I/O connector block for easy connection of I/O signals to the counter/timer devices. The screw terminals are housed in a metal enclosure for protection from noise corruption. Combined with a shielded cable, the SCB-68 provides rugged, very low-noise signal termination. The SCB-68 also includes two general-purpose breadboard areas.

SCB-68 776844-01

Dimensions – 19.5 by 15.2 by 4.5 cm (7.7 by 6.0 by 1.8 in)

Figure 3. SCB-68 Shielded I/O Connector Block

TB-2715 Terminal Block (See Figure 4)

With the TB-2715 terminal block for PXI counter/timer devices, you can connect signals directly without additional cables. Screw terminals provide easy connection of I/O signals. The TB-2715 latches to the front of your PXI module with locking screws and provides strain relief.

TB-2715 778242-01

Dimensions – 8.43 by 10.41 by 2.03 cm (3.32 by 4.1 by 0.8 in.)

Figure 4. TB-2715 I/O Terminal Block

TBX-68 I/O Connector Block with DIN-Rail Mounting (See Figure 5)

Termination accessory with 68 screw terminals for easy connection of field I/O signals to the counter/timer devices. The TBX-68 is mounted in a protective plastic base with hardware for mounting on a standard DIN rail.

TBX-68 777141-01

Dimensions – 12.50 by 10.74 cm (4.92 by 4.23 in.)

Figure 5. TBX-68 I/O Connector Block

CB-68LP and CB-68LPR I/O Connector Blocks (See Figure 6)

Low-cost termination accessories with 68 screw terminals for easy connection of field I/O signals to the counter/timer devices. The connector blocks include standoffs for use on a desktop or mounting in a custom panel. The CB-68LP has a vertically mounted 68-pin connector. The CB-68LPR has a right-angle mounted connector for use with with the CA-1000.

CB-68LP 777145-01

Dimensions – 14.35 by 10.74 cm (5.65 by 4.23 in.)

CB-68LPR 777145-02

Dimensions – 7.62 by 16.19 cm (3.00 by 6.36 in.)

Figure 6. CB-68LP and CB-68LPR I/O Connector Blocks

Counter/Timer Accessories and Cables

Figure 7. RTSI Bus Cable

Figure 8. Extended RTSI Bus Cable

Figure 9. SH68-68-D1 Shielded Cable

Figure 10. R6868 Ribbon I/O Cable

Figure 11. 68-Pin Custom Cable Kit

Cables

RTSI Bus Cables (See Figures 7 and 8)

Use RTSI bus cables to connect timing and synchronization signals among measurement, vision, motion, and CAN boards for PCI. For systems using long and short boards, order the extended RTSI cable.

2 boards 776249-02
3 boards 776249-03
4 boards 776249-04
5 boards 776249-05
Extended, 5 boards 777562-05

SH68-68-D1 Shielded Cable (See Figure 9)

Shielded 68-conductor cable terminated with two 68-pin female 0.050 series D-type connectors. This cable connects counter/timer devices to accessories.

1 m 183432-01
2 m 183432-02

R6868 Ribbon I/O Cable (See Figure 10)

68-conductor flat ribbon cable terminated with two 68-pin connectors. Use this cable to connect the NI PCI-6601 to an accessory. For signal integrity with high-frequency signals, use the SH68-68-D1 with the NI 6602 and NI 6608.

1 m 182482-01

Custom Connectivity Components

68-Pin Custom Cable Connector/Backshell Kit (See Figure 11)

68-pin female mating custom cable kit for use in making custom 68-conductor cables. Solder-cup contacts are available for soldering of cable wires to the connector.

68-pin custom cable kit 776832-01

PCB Mounting Connectors

Printed circuit board (PCB) connectors for use in building custom accessories that connect to 68-conductor shielded and ribbon cables. Two connectors are available, one for right-angle and one for vertical mounting onto a PCB.

68-pin, male, right-angle mounting.....777600-01
68-pin, male, vertical mounting.....777601-01

Low-Cost E Series Multifunction DAQ
12 or 16-Bit, 200 kS/s, 16 Analog Inputs

E Series – Low-Cost

- 16 analog inputs at up to 200 kS/s, 12 or 16-bit resolution
- Up to 2 analog outputs at 10 kS/s, 12 or 16-bit resolution
- 8 digital I/O lines (TTL/CMOS); two 24-bit counter/timers
- Digital triggering
- 4 analog input signal ranges
- NI-DAQ driver simplifies configuration and measurements

Families

- NI 6036E
- NI 6034E
- NI 6025E
- NI 6024E
- NI 6023E

Operating Systems

- Windows 2000/NT/XP
- Real-time performance with LabVIEW
- Others such as Linux and Mac OS X

Recommended Software

- LabVIEW
- LabWindows/CVI
- Measurement Studio
- VI Logger

Other Compatible Software

- Visual Basic, C/C++, and C#

Driver Software (included)

- NI-DAQ 7

Calibration Certificate Included

Family	Bus	Analog Inputs	Input Resolution	Max Sampling Rate	Input Range	Analog Outputs	Output Resolution	Output Rate	Output Range	Digital I/O	Counter/Timers	Triggers
NI 6036E	PCI, PCMCIA	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	2	16 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6034E	PCI	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	0	-	-	-	8	2, 24-bit	Digital
NI 6025E	PCI, PXI	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	2	12 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6024E	PCI, PCMCIA	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	2	12 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6023E	PCI	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	0	-	-	-	8	2, 24-bit	Digital

[1] 10 kS/s typical when using the single DMA channel for analog out put. 1kS/s maximum when using the single DMA channel for either analog input or counter/timer operations. 1 kS/s maximum for PCMCIA DAQCards in all cases.

Table 1. NI Low-Cost E Series Model Guide

Overview and Applications

NI low-cost E Series multifunction data acquisition devices provide full functionality at a price to meet the needs of the budget-conscious user. They are ideal for applications ranging from continuous high-speed data logging to control applications to high-voltage signal or sensor measurements when used with NI signal conditioning. Synchronize the operations of multiple devices using the RTSI bus or PXI trigger bus to easily integrate other hardware such as motion control and machine vision to create an entire measurement and control system.

Highly Accurate Hardware Design

NI Low-Cost E Series DAQ devices include the following features and technologies:

Temperature Drift Protection Circuitry – Designed with components that minimize the effect of temperature changes on measurements to less than 0.0010% of reading per °C.

Resolution-Improvement Technologies – Carefully designed noise floor maximizes the resolution.

Onboard Self-Calibration – Precise voltage reference included for calibration and measurement accuracy. Self-calibration is completely software controlled, with no potentiometers to adjust.

NI DAQ-STC – Timing and control ASIC designed to provide more flexibility, lower power consumption, and a higher immunity to noise and jitter than off-the-shelf counter/timer chips.

NI MITE – ASIC designed to optimize data transfer for multiple simultaneous operations using bus mastering with one DMA channel, interrupts, or programmed I/O.

NI PGIA – Measurement and instrument class amplifier that guarantees settling times at all gains. Typical commercial off-the-shelf amplifier components do not meet the settling time requirements for high-gain measurement applications.

PFI Lines – Eight programmable function input (PFI) lines that can be used for software-controlled routing of interboard and intraboard digital and timing signals.

NATIONAL INSTRUMENTS™

Low-Cost E Series Multifunction DAQ
12 or 16-Bit, 200 kS/s, 16 Analog Inputs

		Full-Featured E Series				Low-Cost E Series		Basic
Models		NI 6030E, NI 6031E, NI 6032E, NI 6033E	NI 6052E	NI 6070E, NI 6071E	NI 6040E	NI 6034E, NI 6036E	NI 6023E, NI 6024E, NI 6025E	PCI-6013, PCI-6014
Measurement Sensitivity* (mV)		0.0023	0.0025	0.009	0.008	0.0036	0.008	0.004
Nominal Range (V)								
Positive FS	**Negative FS**	**Absolute Accuracy (mV)**						
10	-10	1.147	4.747	14.369	15.373	7.560	16.504	8.984
5	-5	2.077	0.876	5.193	5.697	1.790	5.263	2.003
2.5	-2.5	–	1.190	3.605	3.859	–	–	–
2	-2	0.836	–	–	–	–	–	–
1	-1	0.422	0.479	1.452	1.556	–	–	–
0.5	-0.5	0.215	0.243	0.735	0.789	0.399	0.846	0.471
0.25	-0.25	–	0.137	0.379	0.405	–	–	–
0.2	-0.2	0.102	–	–	–	–	–	–
0.1	-0.1	0.061	0.064	0.163	0.176	–	–	–
0.05	-0.05	–	0.035	0.091	0.100	0.0611	0.106	0.069
10	0	0.976	1.232	6.765	7.269	–	–	–
5	0	1.992	2.119	5.391	5.645	–	–	–
2	0	0.802	0.850	2.167	2.271	–	–	–
1	0	0.405	0.428	1.092	1.146	–	–	–
0.5	0	0.207	0.242	0.558	0.583	–	–	–
0.2	0	0.098	0.111	0.235	0.247	–	–	–
0.1	0	0.059	0.059	0.127	0.135	–	–	–

Note: Accuracies are valid for measurements following an internal calibration. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. One-year calibration interval recommended. The Absolute Accuracy at Full Scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 pt averaging of data.*Smallest detectable voltage change in the input signal at the smallest input range.

Table 2. Low-Cost E Series Analog Input Absolute Accuracy Specifications

		Full-Featured E Series				Low-Cost E Series		Basic
Models		NI 6030E, NI 6031E, NI 6032E, NI 6033E	NI 6052E	NI 6070E, NI 6071E	NI 6040E	PCI-6036E	PCI-6024E, NI 6025E,	NI 6013, NI 6014
Nominal Range (V)								
Positive FS	**Negative FS**	**Absolute Accuracy (mV)**						
10	-10	1.43	1.405	8.127	8.127	2.417	8.127	3.835
10	0	1.201	1.176	5.685	5.685	–	–	–

Table 3. Low-Cost E Series Analog Output Absolute Accuracy Specifications

RTSI or PXI Trigger Bus – Used to share timing and control signals between multiple devices to synchronize operations.

RSE Mode – In addition to differential and nonreferenced single-ended modes, NI low-cost E Series devices offer referenced single-ended (RSE) mode for use with floating signal sources in applications with channel counts higher than eight.

Onboard Temperature Sensor – Included for monitoring the operating temperature of the device to ensure that it is operating within the specified range.

High-Performance, Easy-to-Use Driver Software

NI-DAQ is the robust driver software that makes it easy to access the functionality of your data acquisition hardware, whether you are a beginning or advanced user. Helpful features include:

Automatic Code Generation – The DAQ Assistant is an interactive guide that steps you through configuring, testing, and programming measurement tasks and generates the necessary code automatically for LabVIEW, LabWindows/CVI, or Measurement Studio.

Cleaner Code Development – Basic and advanced software functions have been combined into one easy-to-use yet powerful set to help you build cleaner code and move from basic to advanced applications without replacing functions.

High-Performance Driver Engine – Software-timed single-point input (typically used in control loops) with NI-DAQ achieves rates of up to 50 kHz. NI-DAQ also delivers maximum I/O system throughput with a multithreaded driver.

Test Panels – With NI-DAQ, you can test all of your device functionality before you begin development.

Scaled Channels – Easily scale your voltage data into the proper engineering units using the NI-DAQ Measurement Ready virtual channels by choosing from a list of common sensors and signals or creating your own custom scale.

LabVIEW Integration – All NI-DAQ functions create the waveform data type, which carries acquired data and timing information directly into more than 400 LabVIEW built-in analysis routines for display of results in engineering units on a graph.

For information on device support in NI-DAQ 7, visit **ni.com/dataacquisition**

Visit **ni.com/oem** ***for quantity discount information.***

Low-Cost E Series Multifunction DAQ
12 or 16-Bit, 200 kS/s, 16 Analog Inputs

Worldwide Support and Services

NI provides you with a wealth of resources to help you get your application up and running more quickly, including:

Technical Support – Purchase of NI hardware or software gives you access to application engineers all over the world as well as Web resources with more than 3,000 measurement examples and more than 9,000 KnowledgeBase entries. – **ni.com/support**

NI Factory Installation Services (FIS) – Software and hardware installed in PXI and PXI/SCXI systems, tested and ready to use – **ni.com/advisor**

Calibration – Includes NIST-traceable basic calibration certificates, services for ANSI/NCSL-Z540 and periodic calibration – **ni.com/calibration**

Extended Warranty – Meet project life-cycle requirements and maintain optimal performance in a cost-effective way – **ni.com/services**

Data Acquisition Training – Instructor-led courses – **ni.com/training**

Professional Services – Feasibility, consulting, and integration through our Alliance Partners – **ni.com/alliance**

For more information on NI services and support, please visit **ni.com/services**

Recommended Accessories

Signal conditioning is required for sensor measurements or voltage inputs greater than 10 V. National Instruments SCXI is a versatile, high performance signal conditioning platform, intended for high-channel-count applications. NI SCC products provide portable, flexible signal conditioning options on a per-channel basis. Both signal conditioning platforms are designed to increase the performance and reliability of your DAQ System, and are up to 10X more accurate than terminal blocks (please visit **ni.com/sigcon** for more details). Refer to the table below for more information:

Sensor/Signals (>10 V)

System Description	DAQ Device	Signal Conditioning	Page
High performance	PCI-60xxE, PXI-60xxE, DAQCard-60xxE	SCXI	270
Low-cost, portable	PCI-60xxE, PXI-60xxE, DAQCard-60xxE	SCC	251

Signals (<10 V)[1]

System Description	DAQ Device	Terminal Block	Cable	Page
Shielded	PCI-60xxE	SCB-68	SH6868-EP	214
Shielded	PXI-60xxE	TB-2705	SH6868-EP	214
Shielded	DAQCard-60xxE	SCB-68	SHC6868-EP	214
Low-cost	PCI-6025E/PXI-6025E	Two TBX-68s	SH1006868	214
Low-cost	PCI-60xxE/PXI-60xxE	CB-68LP	R6868	214
Low-Cost	DAQCard-60xxE	CB-68LP	RC6868	214

[1] Terminal Blocks do not provide signal conditioning (ie. filtering, amplification, isolation, etc.), which may be necessary to increase the accuracy of your measurements.

Table 4. Recommended Accessories

Ordering Information

NI PCI-6036E.....778465-01
NI DAQCard-6036E.....778561-01
NI PCI-6034E.....778075-01
NI PXI-6025E.....777798-01
NI PCI-6025E.....777744-01
NI DAQCard-6024E.....778269-01
NI PCI-6024E.....777743-01
NI PCI-6023E.....777742-01

Includes NI-DAQ driver software and calibration certificate.

BUY ONLINE!
Visit **ni.com/dataacquisition**

Multifunction DAQ Overview

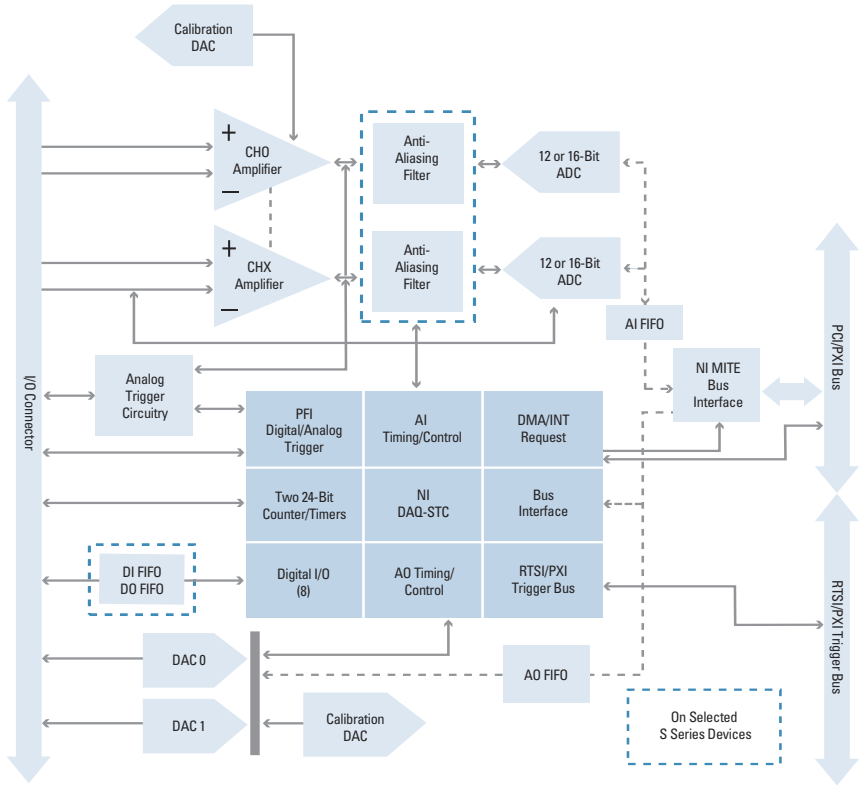


Figure 1. S Series Hardware Block Diagram

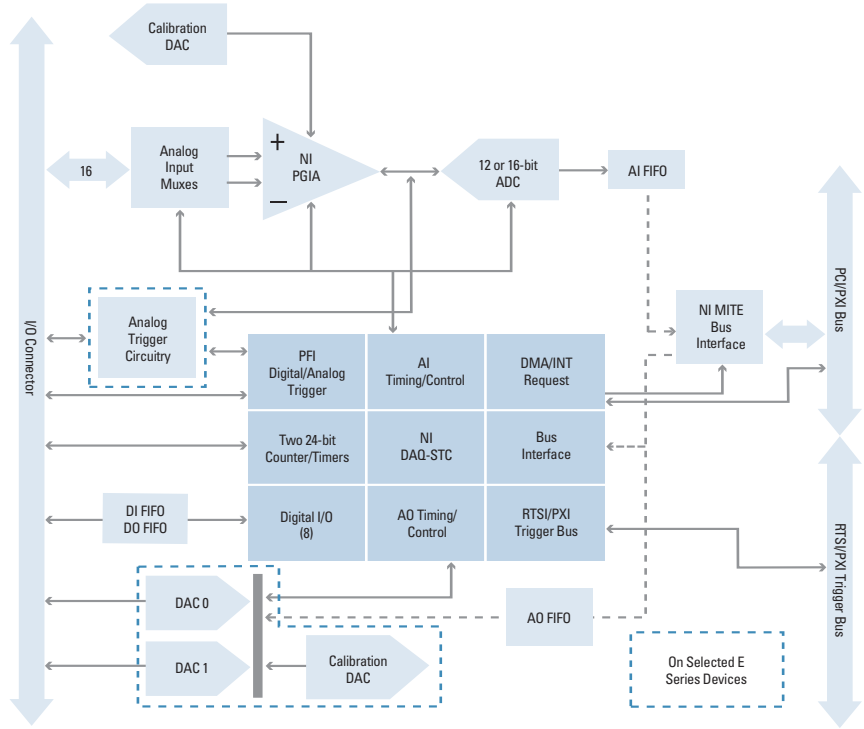


Figure 2. E Series Hardware Block Diagram

12-Bit E Series Multifunction DAQ Specifications

Specifications – NI 607xE, NI 6062E, NI 6040E, NI 602xE

These specifications are typical for 25 °C unless otherwise noted.

Analog Input

Input Characteristics

Number of Channels

6070E 6062E 6040E 602xE	16 single-ended or 8 differential (software selectable per channel)
6071E	64 single-ended or 32 differential (software selectable per channel)

Resolution..... 12 bits, 1 in 4,096

Maximum Sampling Rate

607xE	1.25 MS/s
6062E	500 kS/s
6040E	500 kS/s single-channel scanning 250 kS/s multichannel scanning
6023E 6024E 6025E	200 kS/s
6020E	100 kS/s

Input Signal Ranges

Device	Range (Software Selectable)	Bipolar Input Range	Unipolar Input Range
607xE	20 V	±10 V	–
6062E	10 V	±5 V	0 to 10 V
6040E	5 V	±2.5 V	0 to 5 V
6020E	2 V	±1 V	0 to 2 V
	1 V	±500 mV	0 to 1 V
	500 mV	±250 mV	0 to 500 mV
	200 mV	±100 mV	0 to 200 mV
	100 mV	±50 mV	0 to 100 mV
6023E	20 V	±10 V	–
6024E	10 V	±5 V	–
6025E	1 V	±500 mV	–
	100 mV	±50 mV	–

Input coupling..... DC

Maximum working voltage
(signal + common mode)..... Input should remain within ±11 V of ground

Overvoltage Protection

Device	Powered On	Powered Off
607xE 6062E 6040E	±25 V	±15 V
6023E 6024E 6025E	±40 V	±25 V
6020E	±35 V	±25 V

Inputs Protected

6070E 6062E, 6040E 602xE	AI <0..15>, AI SENSE
6071E	AI <0..63>, AI SENSE, AI SENSE2

FIFO Buffer Size

DAQCard-6062E	8,192 samples
DAQPad-6020E	4,096 samples
DAQPad-6070E DAQCard-6024E	2,048 samples
PCI/PXI-6070E 6071E, 6040E PCI-6023E, NI 6025E, PCI-6024E	512 samples

Data transfers
- PCI, PXI, DAQPad for FireWire..... DMA, interrupts, programmed I/O
- DAQCard, DAQPad for USB..... Interrupts, programmed I/O

DMA modes
- PCI, PXI, DAQPad for FireWire..... Scatter-gather (single-transfer, demand transfer)

Configuration memory size..... 512 words

Transfer Characteristics

Relative Accuracy

Device	Typical Dithered	Maximum Undithered
607xE 6062E 6040E 6023E 6024E 6025E	±0.5 LSB	±1.5 LSB
6020E	±0.2 LSB	±1.5 LSB

DNL

Device	Typical	Maximum
607xE 6040E 6023E PCI-6024E 6025E	±0.5 LSB	±1.0 LSB
6020E	±0.2 LSB	±1.0 LSB
6062E DAQCard-6024E	±0.75 LSB	-0.9, +1.5 LSB

No missing codes..... 12 bits, guaranteed

12-Bit E Series Multifunction DAQ Specifications

Specifications – NI 607xE, NI 606xE, NI 6040E, NI 602xE (continued)

Amplifier Characteristics

Input Impedance

Device	Normal Powered On	Powered Off	Overload
6070E 6062E 6040E PCI-6071E PXI-6071E	100 GΩ in parallel with 100 pF	820 Ω	820 Ω
6023E, 6024E, 6025E	100 GΩ in parallel with 100 pF	4.7 kΩ	4.7 kΩ
6020E	100 GΩ in parallel with 50 pF	3 kΩ	3 kΩ

Input bias current ..... ±200 pA
Input offset current ..... ±100 pA

CMRR, DC to 60 Hz

Device	Range	CMRR (dB)
607xE	20 V	95
	10 V	100
	100 mV to 5 V	106
6040E	10 to 20 V	85
6062E	5 V	95
	100 mV to 2 V	100
6023E	10 to 20 V	85
6024E	100 mV to 1 V	90
6025E		
6020E	100 mV to 20 V	90

Dynamic Characteristics

Bandwidth

Device	Small Signal (-3 dB)	Large Signal (1% THD)
607xE	1.6 MHz	1 MHz
6062E	1.3 MHz	250 kHz
6040E	600 kHz	350 kHz
6023E	500 kHz	225 kHz
PCI-6024E		
6025E		
DAQCard-6024E	500 kHz	265 kHz
DAQPad-6020E	150 kHz	200 kHz

Settling Time to Full-Scale Step

		Accuracy		
Device	Range	±0.012% (±0.5 LSB)	±0.024% (±1 LSB)	±0.098% (±4 LSB)
6070E	20 V	2 µs typical	1.5 µs typical	1.5 µs typical
		3 µs maximum	2 µs maximum	2 µs maximum
	10 V	2 µs typical	1.5 µs typical	1.3 µs typical
		3 µs maximum	2 µs maximum	1.5 µs maximum
	200 mV to 5 V	2 µs typical	1.5 µs typical	0.9 µs typical
		3 µs maximum	2 µs maximum	1 µs maximum
	100 mV	2 µs typical	1.5 µs typical	1 µs typical
		3 µs maximum	2 µs maximum	1.5 µs maximum
6071E	20 V	3 µs typical	1.9 µs typical	1.9 µs typical
		5 µs max	2.5 µs maximum	2 µs maximum
	10 V	3 µs typical	1.9 µs typical	1.2 µs typical
		5 µs maximum	2.5 µs maximum	1.5 µs maximum
	200 mV to 5 V	3 µs typical	1.9 µs typical	1.2 µs typical
		5 µs maximum	2.5 µs maximum	1.3 µs maximum
	100 mV	3 µs typical	1.9 µs typical	1.2 µs typical
		5 µs maximum	2.5 µs maximum	1.5 µs maximum
6062E	All	2.5 µs typical	2.5 µs typical	2 µs typical
		4 µs maximum	3 µs maximum	2.5 µs maximum
	All	4 µs typical	4 µs maximum	4 µs maximum
		8 µs maximum		
	All	5 µs typical	5 µs maximum	5 µs maximum
	All	10 µs maximum	10 µs maximum	10 µs maximum

System Noise (LSB_{rms}, Not Including Quantization)

Device	Range	Dither Off	Dither On
6070E	1 to 20 V	0.25	0.5
6071E	500 mV	0.4	0.6
	200 mV	0.5	0.7
	100 mV	0.8	0.9
6062E	1 to 20 V	0.25	0.6
	500 mV	0.4	0.75
	200 mV	0.5	0.8
	100 mV	0.8	1.0
6040E	1 to 20 V	0.2	0.5
	500 mV	0.25	0.5
	200 mV	0.5	0.7
	100 mV	0.9	1.0
6023E	1 to 20 V	0.1	0.6
PCI-6024E, 6025E	100 mV	0.7	0.8
DAQCard-6024E	10 to 20 V	0.1	0.65
	1 V	0.45	0.65
	100 mV	0.70	0.90
6020E	1 to 20 V	0.07	0.5
	500 mV	0.12	0.5
	200 mV	0.25	0.6
	100 mV	0.5	0.7

Crosstalk, DC to 100 KHz

Device	Adjacent Channels	All Other Channels
607xE, 6062E, 6040E	-75 dB	-90 dB
602xE	-60 dB	-80 dB

12-Bit E Series Multifunction DAQ Specifications

Specifications – NI 607xE, NI 606xE, NI 6040E, NI 602xE (continued)

Analog Output

Output Characteristics

Number of Channels	
607xE 6062E 6040E 6020E 6024E 6025E	2 voltage outputs
6023E	None

Resolution ..... 12 bits, 1 in 4,096

Maximum update rate

Waveform Generation

	FIFO Mode		Non-FIFO Mode	
Device	Internally Timed	Externally Timed	1 Channel	2 Channels
607xE 6040E	1 MS/s	950 kS/s	800 kS/s, system dependent	400 kS/s, system dependent
6062E	850 kS/s	850 kS/s	800 kS/s, system dependent	400 kS/s, system dependent
6023E PCI-6024E 6025E	N/A	N/A	10 kS/s with DMA 1 kS/s with interrupts system dependent	10 kS/s with DMA 1 kS/s with interrupts system dependent
DAQCard-6024E	N/A	N/A	1 kS/s with interrupts system dependent	1 kS/s with interrupts system dependent
DAQPad-6020E	N/A	N/A	20 S/s, system dependent	20 S/s, system dependent

FIFO Buffer Size	
607xE, 6062E	2,048 samples
6040E	512 samples
602xE	None

Data transfers

- PCI, PXI, DAQPad for IEEE 1394 ..... DMA, interrupts, programmed I/O
- DAQCard, DAQPad for USB ..... Interrupts, programmed I/O

DMA modes

- PCI, PXI, DAQPad ..... Scatter-gather (single transfer, demand transfer)

Transfer Characteristics

Relative accuracy

- After calibration
  - 6062E, DAQCard-6024E ..... ±0.5 LSB typical, ±1.0 LSB maximum
  - All others ..... ±0.3 LSB typical, ±0.5 LSB maximum
- Before calibration ..... ±4 LSB maximum

DNL

- After calibration
  - 6062E, DAQCard-6024E ..... ±0.5 LSB typical, ±1.0 LSB maximum
  - All others ..... ±0.3 LSB typical, ±1.0 LSB maximum
- Before calibration ..... ±3 LSB maximum

Monotonicity ..... 12 bits, guaranteed after calibration

Gain error (relative to external reference)

- 6062E, 6020E ..... ±0.5% of output maximum, not adjustable
- 607xE, 6040E ..... 0 to 0.67% of output maximum, not adjustable

Voltage Output

Output coupling ..... DC

Output impedance ..... 0.1 Ω maximum

Ranges	
607xE, 6040E, 6020E	±10 V, 0 to 10 V, ±EXT REF, 0 to EXT REF; software selectable
6062E	±10 V, ±EXT REF, software selectable
6024E, 6025E	±10 V

Current drive ..... ±5 mA maximum

Protection ..... Short-circuit to ground

Power-on state ..... 0 V (±200 mV)

External Reference Input

- Range ..... 11 V
- Overvoltage protection
  - 607xE, 6062E, 6040E ..... ±25 V powered on, ±15 V powered off
  - 6020E ..... ±35 V powered on, ±25 V powered off
- Input impedance ..... 10 kΩ
- Bandwidth (-3 dB)
  - 607xE, 6040E ..... 1 MHz
  - 6062E ..... 50 kHz
  - 6020E ..... 300 kHz

Dynamic Characteristics

Device	Settling Time for Full-Scale Step	Slew Rate
607xE 6062E 6040E	3 µs to ±0.5 LSB accuracy	20 V/µs
602xE	10 µs to ±0.5 LSB accuracy	10 V/µs

Device	Reglitching Disabled	Reglitching Enabled
607xE, 604xE	±20 mV	±4 mV
PCI-6024E 6025E	±42 mV	N/A
DAQCard-6024E	±13 mV	N/A
6020E	±100 mV	N/A
6062E	±80 mV	±30 mV

Glitch Duration (At Mid-Scale Transition)	
607xE 6040E	1.5 µs
6024E 6025E	2 µs
6020E 6062E	3 µs

Noise ..... 200 μV_{rms}, DC to 1 MHz

Glitch energy magnitude (at mid-scale transition)

Stability

Gain temperature coefficient (except 6024E, 6025E)

- External reference ..... ±25 ppm/°C

12-Bit E Series Multifunction DAQ Specifications

Specifications – NI 607xE, NI 606xE, NI 6040E, NI 602xE (continued)

Analog Output

Output Characteristics

Number of Channels	
607xE 6062E 6040E 6020E 6024E 6025E	2 voltage outputs
6023E	None

Resolution ..... 12 bits, 1 in 4,096

Maximum update rate

Waveform Generation

	FIFO Mode		Non-FIFO Mode	
Device	Internally Timed	Externally Timed	1 Channel	2 Channels
607xE 6040E	1 MS/s	950 kS/s	800 kS/s, system dependent	400 kS/s, system dependent
6062E	850 kS/s	850 kS/s	800 kS/s, system dependent	400 kS/s, system dependent
6023E PCI-6024E 6025E	N/A	N/A	10 kS/s with DMA 1 kS/s with interrupts system dependent	10 kS/s with DMA 1 kS/s with interrupts system dependent
DAQCard-6024E	N/A	N/A	1 kS/s with interrupts system dependent	1 kS/s with interrupts system dependent
DAQPad-6020E	N/A	N/A	20 S/s, system dependent	20 S/s, system dependent

FIFO Buffer Size	
607xE, 6062E	2,048 samples
6040E	512 samples
602xE	None

Data transfers

- PCI, PXI, DAQPad for IEEE 1394 ..... DMA, interrupts, programmed I/O
- DAQCard, DAQPad for USB ..... Interrupts, programmed I/O

DMA modes

- PCI, PXI, DAQPad ..... Scatter-gather (single transfer, demand transfer)

Transfer Characteristics

Relative accuracy

- After calibration
  - 6062E, DAQCard-6024E ..... ±0.5 LSB typical, ±1.0 LSB maximum
  - All others ..... ±0.3 LSB typical, ±0.5 LSB maximum
- Before calibration ..... ±4 LSB maximum

DNL

- After calibration
  - 6062E, DAQCard-6024E ..... ±0.5 LSB typical, ±1.0 LSB maximum
  - All others ..... ±0.3 LSB typical, ±1.0 LSB maximum
- Before calibration ..... ±3 LSB maximum

Monotonicity ..... 12 bits, guaranteed after calibration

Gain error (relative to external reference)

- 6062E, 6020E ..... ±0.5% of output maximum, not adjustable
- 607xE, 6040E ..... 0 to 0.67% of output maximum, not adjustable

Voltage Output

Output coupling ..... DC

Output impedance ..... 0.1 Ω maximum

Ranges	
607xE, 6040E, 6020E	±10 V, 0 to 10 V, ±EXT REF, 0 to EXT REF; software selectable
6062E	±10 V, ±EXT REF, software selectable
6024E, 6025E	±10 V

Current drive ..... ±5 mA maximum

Protection ..... Short-circuit to ground

Power-on state ..... 0 V (±200 mV)

External Reference Input

- Range ..... 11 V
- Overvoltage protection
  - 607xE, 6062E, 6040E ..... ±25 V powered on, ±15 V powered off
  - 6020E ..... ±35 V powered on, ±25 V powered off
- Input impedance ..... 10 kΩ
- Bandwidth (-3 dB)
  - 607xE, 6040E ..... 1 MHz
  - 6062E ..... 50 kHz
  - 6020E ..... 300 kHz

Dynamic Characteristics

Device	Settling Time for Full-Scale Step	Slew Rate
607xE 6062E 6040E	3 µs to ±0.5 LSB accuracy	20 V/µs
602xE	10 µs to ±0.5 LSB accuracy	10 V/µs

Device	Reglitching Disabled	Reglitching Enabled
607xE, 604xE	±20 mV	±4 mV
PCI-6024E 6025E	±42 mV	N/A
DAQCard-6024E	±13 mV	N/A
6020E	±100 mV	N/A
6062E	±80 mV	±30 mV

Glitch Duration (At Mid-Scale Transition)	
607xE 6040E	1.5 µs
6024E 6025E	2 µs
6020E 6062E	3 µs

Noise ..... 200 μV_{rms}, DC to 1 MHz

Glitch energy magnitude (at mid-scale transition)

Stability

Gain temperature coefficient (except 6024E, 6025E)

- External reference ..... ±25 ppm/°C

12-Bit E Series Multifunction DAQ Specifications

Specifications – NI 607xE, NI 606xE, NI 6040E, NI 602xE (continued)

Digital I/O

Number of Channels	
6025E	32 input/output
All others	8 input/output

Compatibility ..... 5 V TTL
Power-on state ..... Input; (high-impedance)
Digital logic levels
P0.<0..7>

Level	Minimum (V)	Maximum (V)
Input low voltage	0	0.8
Input high voltage	2.0	5.0
Output low voltage (I_{out} = 24 mA)	–	0.4
Output high voltage (I_{out} = -13 mA)	4.35	–

P1.<0..7>, P2.<0..7>, P3.<0..7>

Level	Minimum (V)	Maximum (V)
Input low voltage	0	0.8
Input high voltage	2.2	5.0
Output low voltage (Iout = 2.5 mA)	–	0.4
Output high voltage (Iout = -2.5 mA)	3.7	–

Data Transfers	
6025E	Interrupts, programmed I/O
All others	Programmed I/O

Transfer rate (1 word = 8 bits)
Maximum with NI-DAQ, system dependent

Transfer Rate	
DAQPad-6070E	5 kwords/s
All others	50 kwords/s

Constant sustainable rate ..... 1 to 10 kwords/s, system dependent

Timing I/O

Number of channels
Up/down counter/timers 2
Frequency scaler 1
Resolution
Up/down counter/timers ..... 24 bits
Frequency scaler ..... 4 bits
Compatibility ..... 5 V/TTL
Base clocks available
Up/down counter/timers ..... 20 MHz and 100 kHz
Frequency scaler ..... 10 MHz and 100 kHz
Base clock accuracy ..... ±0.01%
Maximum source frequency
Up/down counter/timers ..... 20 MHz
Minimum source pulse duration ..... 10 ns, edge-detect mode
Minimum gate pulse duration ..... 10 ns, edge-detect mode
Data transfers ..... DMA*, interrupts, programmed I/O

*Except DAQCard and USB DAQPad

Triggers

Analog Triggers

Number of Triggers	
607xE 6062E 6040E	1
602xE	None

Purpose
Analog input ..... Start and stop trigger, gate, clock
Analog output ..... Start trigger, gate, clock
General-purpose counter/timers ..... Source, gate
Source ..... All analog input channels, PFI 0/AI START TRIG
Level
Internal source, AI<0..15/63> ..... ±Full-scale
External source, PFI 0/AI START TRIG ..... ±10 V
Slope ..... Positive or negative; software selectable
Resolution ..... 8 bits, 1 in 256
Bandwidth (-3 dB)

Device	Internal Source	External Source
607xE	2 MHz	7 MHz
6062E	500 kHz	2.5 MHz
6040E	650 kHz	3 MHz

Hysteresis ..... Programmable

Digital Triggers (All Devices)

Purpose
Analog input ..... Start and stop trigger, gate, clock
Analog output ..... Start trigger, gate, clock
General-purpose counter/timers ..... Source, gate
Source ..... PFI <0..9>, RTSI <0..6>
Compatibility ..... 5 V/TTL
Response ..... Rising or falling edge
Pulse width ..... 10 ns minimum

External Input For Digital Or Analog Trigger (PFI0/TRIG1)

Impedance
6062E ..... 12 kΩ
607xE, 6040E ..... 10 kΩ
Coupling ..... DC
Protection
Digital trigger ..... -0.5 to V_{cc} + 0.5 V

Calibration

Recommended warm-up time ..... 15 minutes; 30 minutes for DAQCard and DAQPad
Calibration interval ..... 1 year
Onboard calibration reference
DC level ..... 5.000 V (±3.5 mV) over full operating temperature, actual value stored in EEPROM
Temperature coefficient ..... ±5 ppm/°C maximum
Long-term stability ..... ±15 ppm/$\sqrt{1000\ h}$

12-Bit E Series Multifunction DAQ Specifications

Specifications – NI 607xE, NI 606xE, NI 6040E, NI 602xE (continued)

RTSI Bus (PCI and FireWire only)

Trigger lines[1]
- PCI 7
- FireWire (DAQPad) 4

PXI Trigger Bus (PXI only)

Trigger lines 6
Star trigger 1

Bus Interface

PCI, PXI, FireWire (DAQPad) ..... Master, slave
USB (DAQPad) ..... Slave
PCMCIA (DAQCard) ..... Slave

Power Requirements[2]

Device	+5 VDC (±5%)*	Power Available at I/O Connector
PCI-607xE, PXI-607xE	1.1 A	+4.65 to +5.25 VDC, 1 A
6040E	1.0 A	+4.65 to +5.25 VDC, 1 A
DAQCard-6062E	340 mA typical 750 mA maximum	+4.65 to +5.25 VDC, 250 mA
DAQCard-6024E	270 mA typical 750 mA maximum	+4.65 to +5.25 VDC, 250 mA
6023E, 6025E, PCI-6024E	0.7 A	+4.65 to +5.25 VDC, 1 A

Device	Power*	Power Available at I/O Connector
DAQPad-6020E	15 W, +9 to +30 VDC	+4.65 to +5.25 VDC, 1 A
DAQPad-6070E	17 W, +9 to +25 VDC	+4.65 to +5.25 VDC, 1 A

*Excludes power consumed through I/O connector

Discharge time with BP-1 battery pack
FireWire (DAQPad) ..... 2.5 hours, typical
USB (DAQPad) ..... 3 hours, typical

Physical[2]

Dimensions (Not Including Connectors)

PCI ..... 17.5 by 10.7 cm (6.9 by 4.2 in.)
PXI ..... 16.0 by 10.0 cm (6.3 by 3.9 in.)
DAQPad (30 cm enclosure) ..... 25.4 by 30.7 by 4.3 cm (10 by 12.1 by 1.7 in.)
DAQPad (15 cm enclosure) ..... 14.6 by 21.3 by 3.8 cm (5.8 by 8.4 by 1.5 in.)
DAQCard ..... Type II PC Card

I/O Connector	
6070E 6040E 6020E 6023E PCI-6024E	68-pin male 0.050 D-type
DAQCard-6062E, DAQCard-6024E	68-pin female VHDCI
6071E 6025E	100-pin female 0.050 D-type

Environment

Operating temperature ..... 0 to 55 °C
0 to 40 °C for DAQCard-6062E and DAQCard-6024E with a maximum internal temperature of 70 °C as measured by onboard temperature sensor; case temperature should not exceed 55 °C for any DAQCard
Storage temperature ..... -20 to 70 °C
Relative humidity ..... 10 to 90%, noncondensing

Certifications and Compliances

CE Mark Compliance CE

[1]Refer to RTSI specifications for available RTSI trigger lines. RTSI not available on DAQCards.
[2]See page 134 for RT Series devices, power requirements and physical parameters.

Multifunction DAQ Cable and Accessory Selection Guides

NI Cable Design Advantages

The SH68-68-EP cable is the most commonly used E Series and S Series cable. The cable is designed to work specifically with the NI Multifunction DAQ devices to preserve signal integrity through these technologies:

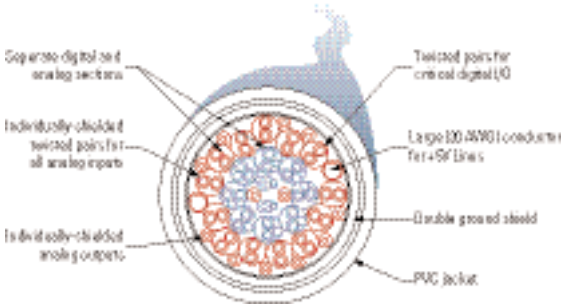


Figure 1. SH68-68-EP Cable

A variety of cabling and accessory options are available for your needs. Use the following tables to choose the most appropriate cables and accessories.

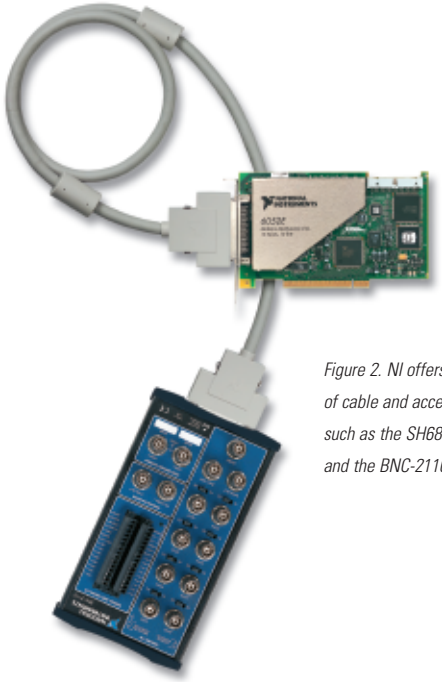


Figure 2. NI offers a wide variety of cable and accessory options, such as the SH68-68-EP cable and the BNC-2110 terminal block.

Platform	Shielding	Connect to ...	Cable	Adapter	Accessory
PCI/PXI/USB/FireWire					
	Shielded	SCC portable signal conditioning per channel	SH68-68-EP	–	SC-2345 and modules, page 251
	Shielded	SCXI high-performance signal conditioning	SCXI-1349	–	SCXI Chassis and Modules, page 270
	Shielded	Screw terminals [1]	SH68-68-EP or SH68-68R1-EP	–	SCB-68
	Shielded	BNC terminal block	SH68-68-EP	–	BNC-2110, BNC-2120, BNC-2090
	Shielded	50-pin connector	SH6850	–	CB50, custom or 3rd party
	Shielded	Configurable connectivity box	SH68-68-EP	–	CA-1000, page 351
	Unshielded	Screw terminals [1]	R6868	–	TBX-68, CB-68LP, CB-68LPR, DAQ signal accessory
	Unshielded	50-pin connector	R6850	–	CB50, custom or 3rd party
PXI only					
	Shielded	Front-mounted screw terminals	N/A	–	TB-2705
PCMCIA					
	Shielded	Screw terminals [1]	SHC68-68-EP or SHC68U-68-EP [2]	–	SCB-68, CA-1000
	Shielded	50-pin connector	SHC68-68-EP or SHC68U-68-EP [2]	68M-50F MIO	CB50, custom or 3rd party
	Unshielded	Screw terminals [1]	RC68-68		TBX-68, CB-68LP, CB-68LPR, DAQ signal accessory
	Unshielded	50-pin connector	RC68-68	68M-50F MIO	CB50, custom or 3rd party

[1] Unshielded cables can connect to shielded accessories and vice-versa. [2] In adjacent PCMCIA slots, both cables types are required because the same cable would cause mechanical hindrance.

Table 1. Cable Connection Specifications for 16-Channel E Series Devices and Basic Multifunction DAQ (except NI 6025E, which is on the next page)

Multifunction DAQ Cable and Accessory Selection Guides

AI 0-	34	68	AI 0+
AI 1+	33	67	AI 0 GND
AI 1 GND	32	66	AI 1-
AI 2-	31	65	AI 2+
AI 3+	30	64	AI 2 GND
AI 3 GND	29	63	AI 3-
NC	28	62	NC
NC	27	61	NC
NC	26	60	NC
NC	25	59	NC
NC	24	58	NC
NC	23	57	NC
AO 0	22	56	NC
AO 0	21	55	AO GND
EXT REF	20	54	AO GND
P0.4	19	53	D GND
D GND	18	52	P0.0
P0.1	17	51	P0.5
P0.6	16	50	D GND
D GND	15	49	P0.2
+5 V	14	48	P0.7
D GND	13	47	P0.3
D GND	12	46	AI HOLD
PFI 0/AI START	11	45	EXT STROBE
PFI 1/REF TRIG	10	44	D GND
D GND	9	43	PFI 2/AI CONV
+5 V	8	42	PFI 3/CTR 1 SRC
D GND	7	41	PFI 4/CTR1 GATE
PFI 5/AO SAMP	6	40	CTR 1 OUT
PFI 6/AO START	5	39	D GND
D GND	4	38	PFI 7/AI SAMP
PFI 9/CTR 0 GATE	3	37	PFI 8/CTR 0 SRC
CTR 0 OUT	2	36	D GND
F OUT	1	35	D GND

Figure 3. S Series Devices Connector

[1]No connects for boards that do not support AO or use an external reference with the SH1006868 cable.

AI 8	34	68	AI 0
AI 1	33	67	AI GND
AI GND	32	66	AI 9
AI 10	31	65	AI 2
AI 3	30	64	AI GND
AI GND	29	63	AI 11
AI 4	28	62	AI SENSE
AI GND	27	61	AI 12
ACH13	26	60	AI 5
ACH6	25	59	AI GND
AIGND	24	58	AI 14
ACH15	23	57	AI 7
AO 0[1]	22	56	AI GND
AO 1[1]	21	55	AO GND
EXT REF[1]	20	54	AO GND
P0.4	19	53	D GND
D GND	18	52	P0.0
P0.1	17	51	P0.5
P0.6	16	50	D GND
D GND	15	49	P0.2
+5 V	14	48	P0.7
D GND	13	47	P0.3
D GND	12	46	AI HOLD
PFI 0/AI START	11	45	EXT STROBE
PFI 1/REF TRIG	10	44	D GND
D GND	9	43	PFI 2/AI CONV
+5 V	8	42	PFI 3/AI CTR 1 SRC
D GND	7	41	PFI 4/AI CTR 1 GATE
PFI 5/AO SAMP	6	40	CTR 1 OUT
PFI 6/AO START	5	39	D GND
DGND	4	38	PFI 7/AI SAMP
PFI 9/CTR 0 GATE	3	37	PFI 8/CTR 0 SRC
CTR 0 OUT	2	36	D GND
F OUT	1	35	D GND

Figure 4. I/O Connector for 16-Channel E Series and Basic Multifunction DAQ Devices, except NI 6025E

AI GND	1	51	AI 16
AI GND	2	52	AI 24
AI 0	3	53	AI 17
AI 8	4	54	AI 25
AI 1	5	55	AI 18
AI 9	6	56	AI 26
AI 2	7	57	AI 19
AI 10	8	58	AI 27
AI 3	9	59	AI 20
AI 11	10	60	AI 28
AI 4	11	61	AI 21
AI 12	12	62	AI 29
AI 5	13	63	AI 22
AI 13	14	64	AI 30
AI 6	15	65	AI 23
AI 14	16	66	AI 31
AI 7	17	67	AI 32
AI 15	18	68	AI 40
AI SENSE	19	69	AI 33
AO 0	20	70	AI 41
AO 1	21	71	AI 34
EXT REF	22	72	AI 42
AO GND	23	73	AI 35
D GND	24	74	AI 43
P0.0	25	75	AI SENSE 2
P0.4	26	76	AI GND
P0.1	27	77	AI 36
P0.5	28	78	AI 44
P0.2	29	79	AI 37
P0.6	30	80	AI 45
P0.3	31	81	AI 38
P0.7	32	82	AI 46
D GND	33	83	AI 39
+5 V	34	84	AI 47
+5 V	35	85	AI 48
AI HOLD	36	86	AI 56
EXT STROBE	37	87	AI 49
PFI 0/AI START	38	88	AI 57
PFI 1/REF TRIG	39	89	AI 50
PFI 2/AI CONV	40	90	AI 58
PFI 3/CTR 1 SRC	41	91	AI 51
PFI 4/CTR 1 GATE	42	92	AI 59
CTR 1 OUT	43	93	AI 52
PFI 5/AO SAMP	44	94	AI 60
PFI 6/AO START	45	95	AI 53
PFI 7/AI SAMP	46	96	AI 61
PFI 8/CTR 0 SRC	47	97	AI 54
PFI 9/CTR 0 GATE	48	98	AI 62
CTR 0 OUT	49	99	AI 55
F OUT	50	100	AI 63

Figure 5. I/O Connector for 64-Channel E Series Devices

AI GND	1	51	P3.7
AI GND	2	52	GND
AI 0	3	53	P3.6
AI 8	4	54	GND
AI 1	5	55	P3.5
AI 9	6	56	GND
AI 2	7	57	P3.4
AI 10	8	58	GND
AI 3	9	59	P3.3
AI 11	10	60	GND
AI 4	11	61	P3.2
AI 12	12	62	GND
AI 5	13	63	P3.1
AI 13	14	64	GND
AI 6	15	65	P3.0
AI 14	16	66	GND
AI 7	17	67	P2.7
AI 15	18	68	GND
AI SENSE	19	69	P2.6
AO 0	20	70	GND
AO 1	21	71	P2.5
NC	22	72	GND
AO GND	23	73	P2.4
D GND	24	74	GND
P1.0	25	75	P2.3
P1.4	26	76	GND
P1.1	27	77	P2.2
P1.5	28	78	GND
P1.2	29	79	P2.1
P1.6	30	80	GND
P1.3	31	81	P2.0
P1.7	32	82	GND
D GND	33	83	P1.7
+5 V	34	84	GND
+5 V	35	85	P1.6
AI HOLD	36	86	GND
EXT STROBE	37	87	P1.5
PFI 0/AI START	38	88	GND
PFI 1/REF TRIG	39	89	P1.4
PFI 2/AI CONV	40	90	GND
PFI 3/CTR 1 SRC	41	91	P1.3
PFI 4/CTR 1 GATE	42	92	GND
CTR 1 OUT	43	93	P1.2
PFI 5/AO SAMP	44	94	GND
PFI 6/AO START	45	95	P1.1
PFI 7/AI SAMP	46	96	GND
PFI 8/CTR 0 SRC	47	97	P1.0
PFI 9/CTR 0 GATE	48	98	GND
CTR 0 OUT	49	99	+5 V
F OUT	50	100	GND

Figure 6. I/O Connector for the NI 6025E Device

E Series Devices (NI 6031E, NI 6033E, NI 6071E, NI 6025E)

Platform	Shielding	Connect to ...	Cable	Cable Leg	Adapter	Accessory
PCI, PXI						
	Shielded	Screw terminals	SH100100	–	–	SCB-100
	Shielded	Screw terminals	SH1006868	MIO:	–	SCB-68
	Shielded		SH1006868	Extended:	–	SCB-68
	Shielded	Screw terminals[1]	SH1006868	MIO:	–	TBX-68, CB-68LP, CB-68LPR, DAQ signal accessory
	Shielded	Screw terminals[1]	SH1006868	Extended:	–	TBX-68, CB-68LP, CB-68LPR
	Shielded	BNC terminal block	SH1006868	MIO:	–	BNC-2110, BNC-2120, BNC-2090
	Shielded		SH1006868	Extended:	–	BNC-2115
	Shielded	50-pin connectors	SH1006868	MIO:	68M-50F MIO	Custom or 3rd party
	Shielded		SH1006868	Extended:	68M-50F Extended	Custom or 3rd party
	Unshielded	50-pin connector	R1005050	MIO:	–	Custom or 3rd party
	Unshielded		R1005050	Extended:	–	Custom or 3rd party

[1]Shielded cable with unshielded accessories

Table 2. Cable Connection Specifications for 64-Channel E Series Devices and the NI 6025E

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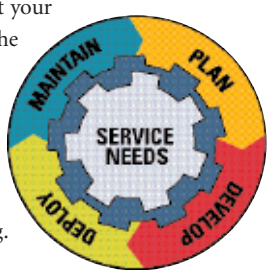

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DAQ

6023E/6024E/6025E User Manual

Multifunction I/O Devices for PCI, PXI™, CompactPCI, and PCMCIA Bus Computers

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Worldwide Technical Support and Product Information

ni.com

National Instruments Corporate Headquarters

11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 794 0100

Worldwide Offices

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011,
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Contents

About This Manual

Conventions Used in This Manual xi
Related Documentation xii

Chapter 1
Introduction

Features of the 6023E, 6024E, and 6025E 1-1
Using PXI with CompactPCI 1-2
What You Need to Get Started 1-2
Software Programming Choices 1-3
    National Instruments Application Software 1-3
    NI-DAQ Driver Software 1-4
Optional Equipment 1-5

Chapter 2
Installation and Configuration

Software Installation 2-1
Unpacking 2-1
Hardware Installation 2-2
Hardware Configuration 2-3

Chapter 3
Hardware Overview

Analog Input 3-2
    Input Mode 3-2
    Input Range 3-3
    Dithering 3-4
    Multichannel Scanning Considerations 3-5
Analog Output 3-6
    Analog Output Glitch 3-6
Digital I/O 3-7
Timing Signal Routing 3-7
    Programmable Function Inputs 3-8
    Device and RTSI Clocks 3-9
    RTSI Triggers 3-9

Chapter 4
Signal Connections

I/O Connector 4-1
Analog Input Signal Overview 4-8
Types of Signal Sources 4-8
Floating Signal Sources 4-9
Ground-Referenced Signal Sources 4-9
Analog Input Modes 4-9
Analog Input Signal Connections 4-11
Differential Connection Considerations (DIFF Input Configuration) 4-13
Differential Connections for Ground-Referenced Signal Sources 4-14
Differential Connections for Nonreferenced or Floating Signal Sources 4-15
Single-Ended Connection Considerations 4-17
Single-Ended Connections for Floating Signal Sources (RSE Configuration) 4-18
Single-Ended Connections for Grounded Signal Sources (NRSE Configuration) 4-18
Common-Mode Signal Rejection Considerations 4-19
Analog Output Signal Connections 4-19
Digital I/O Signal Connections 4-20
All Devices 4-20
Programmable Peripheral Interface (PPI) 4-22
Port C Pin Assignments 4-23
Power-up State 4-24
Changing DIO Power-up State to Pulled Low 4-24
Timing Specifications 4-25
Mode 1 Input Timing 4-27
Mode 1 Output Timing 4-28
Mode 2 Bidirectional Timing 4-29
Power Connections 4-30
Timing Connections 4-30
Programmable Function Input Connections 4-31
DAQ Timing Connections 4-32
SCANCLK Signal 4-33
EXTSTROBE* Signal 4-33
TRIG1 Signal 4-34
TRIG2 Signal 4-35
STARTSCAN Signal 4-36
CONVERT* Signal 4-38
AIGATE Signal 4-39
SISOURCE Signal 4-40

Waveform Generation Timing Connections 4-40
WFTRIG Signal 4-40
UPDATE* Signal....4-41
UISOURCE Signal 4-42
General-Purpose Timing Signal Connections 4-43
GPCTR0_SOURCE Signal....4-43
GPCTR0_GATE Signal....4-44
GPCTR0_OUT Signal 4-45
GPCTR0_UP_DOWN Signal....4-45
GPCTR1_SOURCE Signal....4-46
GPCTR1_GATE Signal....4-46
GPCTR1_OUT Signal 4-47
GPCTR1_UP_DOWN Signal....4-47
FREQ_OUT Signal....4-49
Field Wiring Considerations....4-49

Chapter 5
Calibration

Loading Calibration Constants 5-1
Self-Calibration....5-2
External Calibration....5-2
Other Considerations 5-3

Appendix A
Specifications

Appendix B
Custom Cabling and Optional Connectors

Appendix C
Common Questions

Appendix D
Technical Support Resources

Glossary

Index

Figures

Figure 1-1. The Relationship Between the Programming Environment, NI-DAQ, and Your Hardware 1-5

Figure 3-1. PCI-6023E, PCI-6024E, PCI-6025E, and PXI-6025E Block Diagram 3-1
Figure 3-2. DAQCard-6024E Block Diagram 3-2
Figure 3-3. Dithering 3-5
Figure 3-4. CONVERT* Signal Routing 3-8
Figure 3-5. PCI RTSI Bus Signal Connection 3-10
Figure 3-6. PXI RTSI Bus Signal Connection 3-11

Figure 4-1. I/O Connector Pin Assignment for the 6023E/6024E 4-2
Figure 4-2. I/O Connector Pin Assignment for the 6025E 4-3
Figure 4-3. Programmable Gain Instrumentation Amplifier (PGIA) 4-10
Figure 4-4. Summary of Analog Input Connections 4-12
Figure 4-5. Differential Input Connections for Ground-Referenced Signals 4-14
Figure 4-6. Differential Input Connections for Nonreferenced Signals 4-15
Figure 4-7. Single-Ended Input Connections for Nonreferenced or Floating Signals 4-18
Figure 4-8. Single-Ended Input Connections for Ground-Referenced Signals 4-19
Figure 4-9. Analog Output Connections 4-20
Figure 4-10. Digital I/O Connections 4-21
Figure 4-11. Digital I/O Connections Block Diagram 4-22
Figure 4-12. DIO Channel Configured for High DIO Power-up State with External Load 4-24
Figure 4-13. Timing Specifications for Mode 1 Input Transfer 4-27
Figure 4-14. Timing Specifications for Mode 1 Output Transfer 4-28
Figure 4-15. Timing Specifications for Mode 2 Bidirectional Transfer 4-29
Figure 4-16. Timing I/O Connections 4-31
Figure 4-17. Typical Posttriggered Acquisition 4-32
Figure 4-18. Typical Pretriggered Acquisition 4-33
Figure 4-19. SCANCLK Signal Timing 4-33
Figure 4-20. EXTSTROBE* Signal Timing 4-34
Figure 4-21. TRIG1 Input Signal Timing 4-34
Figure 4-22. TRIG1 Output Signal Timing 4-35
Figure 4-23. TRIG2 Input Signal Timing 4-36
Figure 4-24. TRIG2 Output Signal Timing 4-36
Figure 4-25. STARTSCAN Input Signal Timing 4-37
Figure 4-26. STARTSCAN Output Signal Timing 4-37
Figure 4-27. CONVERT* Input Signal Timing 4-38
Figure 4-28. CONVERT* Output Signal Timing 4-39
Figure 4-29. SISOURCE Signal Timing 4-40

Figure 4-30. WFTRIG Input Signal Timing 4-41
Figure 4-31. WFTRIG Output Signal Timing 4-41
Figure 4-32. UPDATE* Input Signal Timing 4-42
Figure 4-33. UPDATE* Output Signal Timing 4-42
Figure 4-34. UISOURCE Signal Timing 4-43
Figure 4-35. GPCTR0_SOURCE Signal Timing 4-44
Figure 4-36. GPCTR0_GATE Signal Timing in Edge-Detection Mode 4-45
Figure 4-37. GPCTR0_OUT Signal Timing 4-45
Figure 4-38. GPCTR1_SOURCE Signal Timing 4-46
Figure 4-39. GPCTR1_GATE Signal Timing in Edge-Detection Mode 4-47
Figure 4-40. GPCTR1_OUT Signal Timing 4-47
Figure 4-41. GPCTR Timing Summary 4-48

Figure B-1. 68-Pin E Series Connector Pin Assignments B-3
Figure B-2. 68-Pin Extended Digital Input Connector Pin Assignments B-4
Figure B-3. 50-Pin E Series Connector Pin Assignments B-5
Figure B-4. 50-Pin Extended Digital Input Connector Pin Assignments B-6

Tables

Table 3-1. Available Input Configurations 3-3
Table 3-2. Measurement Precision 3-3
Table 3-3. Pins Used by PXI E Series Device 3-11

Table 4-1. I/O Connector Details 4-1
Table 4-2. I/O Connector Signal Descriptions 4-4
Table 4-3. I/O Signal Summary 4-7
Table 4-4. Port C Signal Assignments 4-23
Table 4-5. Signal Names Used in Timing Diagrams 4-25

About This Manual

The 6023, 6024, and 6025 E Series boards are high-performance multifunction analog, digital, and timing I/O boards for PCI, PXI, PCMCIA, and CompactPCI bus computers. Supported functions include analog input, analog output, digital I/O, and timing I/O.

This manual describes the electrical and mechanical aspects of the PCI-6023E, PCI-6024E, DAQCard-6024E, PCI-6025E, and PXI-6025E boards from the E Series product line and contains information concerning their operation and programming.

Conventions Used in This Manual

The following conventions are used in this manual:

<>	Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.
♦	The ♦ symbol indicates that the text following it applies only to a specific product, a specific operating system, or a specific software version.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
bold	Bold text denotes items that you must select or click on in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
CompactPCI	CompactPCI refers to the core specification defined by the PCI Industrial Computer Manufacturer's Group (PICMG).
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Monospace font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories,

	programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.
NI-DAQ	NI-DAQ refers to the NI-DAQ driver software for PC compatible computers unless otherwise noted.
PXI	PXI stands for PCI eXtensions for Instrumentation. PXI is an open specification that builds off the CompactPCI specification by adding instrumentation-specific features.

Related Documentation

The following documents contain information you may find helpful:

- *DAQ-STC Technical Reference Manual*
- National Instruments Application Note 025, *Field Wiring and Noise Considerations for Analog Signals*
- *PCI Local Bus Specification Revision 2.2*
- *PICMG CompactPCI 2.0 R2.1*
- *PXI Specification Revision 2.0*
- *PC Card (PCMCIA) 7.1 Standard*

1 Introduction

This chapter describes the 6023E, 6024E, and 6025E devices, lists what you need to get started, gives unpacking instructions, and describes the optional software and equipment.

Features of the 6023E, 6024E, and 6025E

The 6025E features 16 channels (eight differential) of analog input, two channels of analog output, a 100-pin connector, and 32 lines of digital I/O. The 6024E features 16 channels of analog input, two channels of analog output, a 68-pin connector and eight lines of digital I/O. The 6023E is identical to the 6024E, except that it does not have analog output channels.

These devices use the National Instruments DAQ-STC system timing controller for time-related functions. The DAQ-STC consists of three timing groups that control analog input, analog output, and general-purpose counter/timer functions. These groups include a total of seven 24-bit and three 16-bit counters and a maximum timing resolution of 50 ns. The DAQ-STC makes possible such applications as buffered pulse generation, equivalent time sampling, and seamless changing of the sampling rate.

- PCI-6023E, PCI-6024E, PCI-6025E, and PXI-6025E only

  With many DAQ devices, you cannot easily synchronize several measurement functions to a common trigger or timing event. These devices have the Real-Time System Integration (RTSI) bus to solve this problem. In a PCI system, the RTSI bus consists of the National Instruments RTSI bus interface and a ribbon cable to route timing and trigger signals between several functions on as many as five DAQ devices in your computer. In a PXI system, the RTSI bus consists of the National Instruments RTSI bus interface and the PXI trigger signals on the PXI backplane to route timing and trigger signals between several functions on as many as seven DAQ devices in your system.

These devices can interface to an SCXI system—the instrumentation front end for plug-in DAQ devices—so that you can acquire analog signals from thermocouples, RTDs, strain gauges, voltage sources, and current sources. You can also acquire or generate digital signals for communication and control.

Using PXI with CompactPCI

Using PXI compatible products with standard CompactPCI products is an important feature provided by *PXI Specification, Revision 1.0*. If you use a PXI compatible plug-in card in a standard CompactPCI chassis, you cannot use PXI-specific functions, but you can still use the basic plug-in card functions. For example, the RTSI bus on your PXI E Series device is available in a PXI chassis, but not in a CompactPCI chassis.

The CompactPCI specification permits vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses nor between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these sub-buses. Your PXI E Series device works in any standard CompactPCI chassis adhering to *PICMG CompactPCI 2.0 R2.1* core specification.

PXI specific features are implemented on the J2 connector of the CompactPCI bus. Table 3-3, *Pins Used by PXI E Series Device*, lists the J2 pins used by your PXI E Series device. Your PXI device is compatible with any Compact PCI chassis with a sub-bus that does not drive these lines. Even if the sub-bus is capable of driving these lines, the PXI device is still compatible as long as those pins on the sub-bus are disabled by default and not ever enabled. Damage can result if these lines are driven by the sub-bus.

What You Need to Get Started

To set up and use your device, you need the following:

- ❑ One of the following devices:
  - PCI-6023E
  - PCI-6024E
  - PCI-6025E
  - PXI-6025E
  - DAQCard-6024E

- ❑ *6023E/6024E/6025E User Manual*
- ❑ One of the following software packages and documentation:
  - LabVIEW for Windows
  - Measurement Studio
  - VirtualBench
- ❑ NI-DAQ for PC Compatibles
- ❑ Your computer equipped with one of the following:
  - PCI bus for a PCI device
  - PXI or CompactPCI chassis and controller for a PXI device
  - Type II PCMCIA slot for a DAQCard device

Note Read Chapter 2, *Installation and Configuration*, before installing your device. Always install your software before installing your device.

Software Programming Choices

When programming your National Instruments DAQ and SCXI hardware, you can use National Instruments application software or another application development environment (ADE). In either case, you use NI-DAQ.

National Instruments Application Software

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW Data Acquisition VI Library, a series of virtual instruments for using LabVIEW with National Instruments DAQ hardware, is included with LabVIEW. The LabVIEW Data Acquisition VI Library is functionally equivalent to NI-DAQ software.

Measurement Studio, which includes LabWindows/CVI, tools for Visual C++, and tools for Visual Basic, is a development suite that allows you to use ANSI C, Visual C++, and Visual Basic to design your test and measurement software. For C developers, Measurement Studio includes LabWindows/CVI, a fully integrated ANSI C application development environment that features interactive graphics and the LabWindows/CVI Data Acquisition and Easy I/O libraries. For Visual Basic developers, Measurement Studio features a set of ActiveX controls for using National Instruments DAQ hardware. These ActiveX controls provide a high-level

programming interface for building virtual instruments. For Visual C++ developers, Measurement Studio offers a set of Visual C++ classes and tools to integrate those classes into Visual C++ applications. The libraries, ActiveX controls, and classes are available with Measurement Studio and the NI-DAQ software.

VirtualBench features virtual instruments that combine DAQ products, software, and your computer to create a stand-alone instrument with the added benefit of the processing, display, and storage capabilities of your computer. VirtualBench instruments load and save waveform data to disk in the same forms that can be used in popular spreadsheet programs and word processors.

Using LabVIEW, Measurement Studio, or VirtualBench software greatly reduces the development time for your data acquisition and control application.

NI-DAQ Driver Software

The NI-DAQ driver software shipped with your 6023E/6024E/6025E is compatible with you device. It has an extensive library of functions that you can call from your application programming environment. These functions allow you to use all features of your 6023E/6024E/6025E.

NI-DAQ addresses many of the complex issues between the computer and the DAQ hardware such as programming interrupts. NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code. Whether you are using LabVIEW, Measurement Studio, or other programming languages, your application uses the NI-DAQ driver software, as illustrated in Figure 1-1.

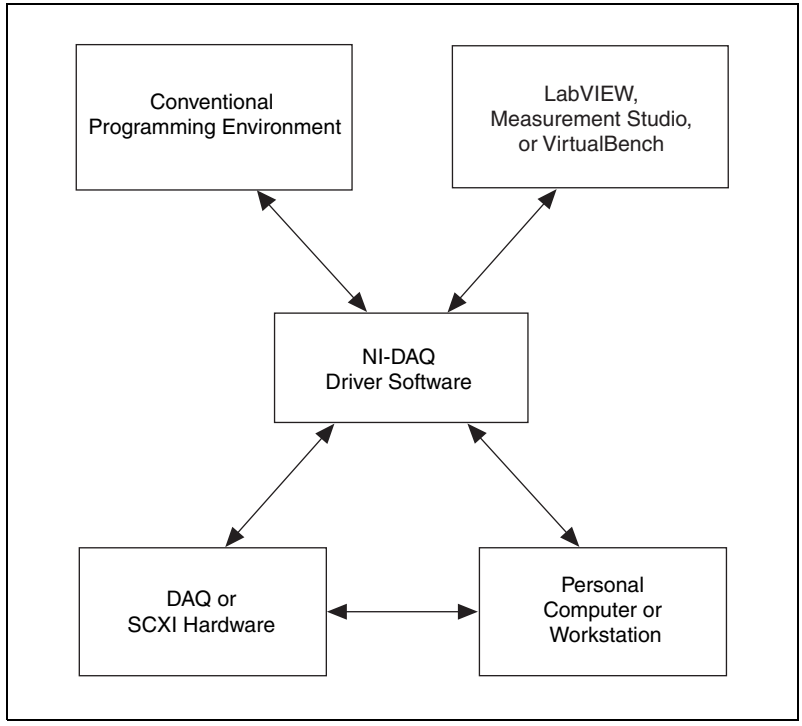


Figure 1-1. The Relationship Between the Programming Environment, NI-DAQ, and Your Hardware

To download a free copy of the most recent version of NI-DAQ, click **Download Software** at `ni.com`.

Optional Equipment

National Instruments offers a variety of products to use with your device, including cables, connector blocks, and other accessories, as follows:

- Cables and cable assemblies, shielded and ribbon
- Connector blocks, shielded and unshielded screw terminals
- RTSI bus cables
- SCXI modules and accessories for isolating, amplifying, exciting, and multiplexing signals for relays and analog output. With SCXI you can condition and acquire up to 3,072 channels.
- Low channel count signal conditioning modules, devices, and accessories, including conditioning for strain gauges and RTDs, simultaneous sample and hold, and relays

For more information about these products, refer to the National Instruments catalogue or web site or call the office nearest you.

2

Installation and Configuration

This chapter explains how to install and configure your 6023E, 6024E, or 6025E device.

Software Installation

Install your software before installing your device.

If you are using LabVIEW, LabWindows/CVI, ComponentWorks, or VirtualBench, install this software before installing the NI-DAQ driver software. Refer to the software release notes of your software for installation instructions.

If you are using NI-DAQ, refer to your NI-DAQ release notes. Find the installation section for your operating system and follow the instructions given there.

Unpacking

Your device is shipped in an antistatic package to prevent electrostatic damage to the device. Electrostatic discharge can damage several components on the device. To avoid such damage in handling the device, take the following precautions:

- Ground yourself by using a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the device from the package.
- Remove the device from the package and inspect the device for loose components or any other sign of damage. Notify National Instruments if the device appears damaged in any way. Do *not* install a damaged device into your computer.

Never touch the exposed pins of connectors.

Hardware Installation

After installing your software, you are ready to install your hardware. Your device will fit in any available slot in your computer. However, to achieve best noise performance, leave as much room as possible between your device and other devices. The following are general installation instructions. Consult your computer user manual or technical reference manual for specific instructions and warnings.

- PCI device installation
  1. Turn off and unplug your computer.
  2. Remove the top cover of your computer.
  3. Remove the expansion slot cover on the back panel of the computer.
  4. Touch any metal part of your computer chassis to discharge any static electricity that might be on your clothes or body.
  5. Insert the device into a 5 V PCI slot. Gently rock the device to ease it into place. It may be a tight fit, but *do not force* the device into place.
  6. Screw the mounting bracket of the device to the back panel rail of the computer.
  7. Visually verify the installation.
  8. Replace the top cover of your computer.
  9. Plug in and turn on your computer.

- PCMCIA card installation

  Insert the DAQCard into any available Type II PCMCIA slot until the connector is seated firmly. Insert the card face-up. It is keyed so that you can only insert it one way.

- PXI device installation
  1. Turn off and unplug your computer.
  2. Choose an unused PXI slot in your system. For maximum performance, the device has an onboard DMA controller that you can only use if the device is installed in a slot that supports bus arbitration, or bus master cards. National Instruments recommends installing the device in such a slot. The PXI specification requires all slots to support bus master cards, but the CompactPCI specification does not. If you install in a CompactPCI non-master slot, you must disable the onboard DMA controller of the device using software.
  3. Remove the filler panel for the slot you have chosen.

4. Touch any metal part of your computer chassis to discharge any static electricity that might be on your clothes or body.
5. Insert the device into a 5 V PXI slot. Use the injector/ejector handle to fully insert the device into the chassis.
6. Screw the front panel of the device to the front panel mounting rail of the system.
7. Visually verify the installation.
8. Plug in and turn on your computer.

The device is installed. You are now ready to configure your hardware and software.

Hardware Configuration

National Instruments standard architecture for data acquisition and standard bus specifications, makes these devices completely software-configurable. You must perform two types of configuration on the devices—bus-related and data acquisition-related configuration.

The PCI devices are fully compatible with the industry-standard *PCI Local Bus Specification Revision 2.2*. The PXI device is fully compatible with the *PXI Specification Revision 2.0*. These specifications let your computer automatically set the device base memory address and interrupt channel without your interaction.

You can modify data acquisition-related configuration settings, such as analog input range and mode, through application-level software. Refer to Chapter 3, *Hardware Overview,* for more information about the various settings available for your device. These settings are changed and configured through software after you install your device. Refer to your software documentation for configuration instructions.

3

Hardware Overview

This chapter presents an overview of the hardware functions on your device.

Figure 3-1 shows a block diagram for the PCI-6023E, PCI-6024E, PCI-6025E, and PXI-6025E.

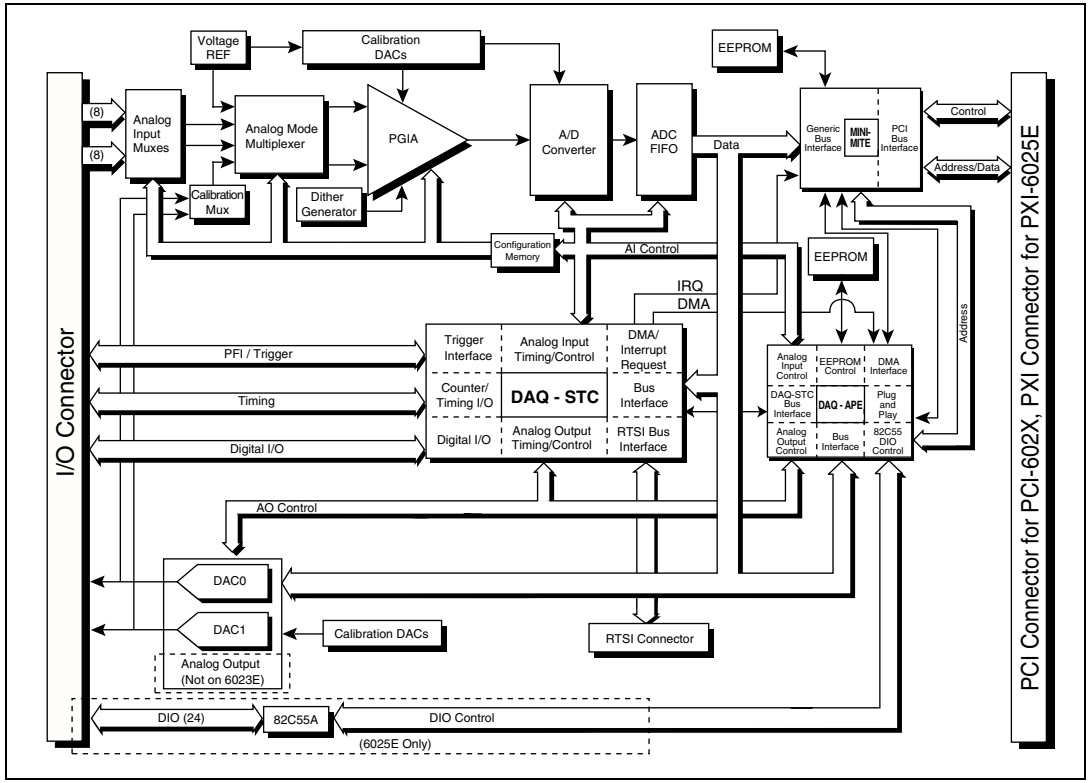


Figure 3-1. PCI-6023E, PCI-6024E, PCI-6025E, and PXI-6025E Block Diagram

Figure 3-2 shows the block diagram for the DAQCard-6024E.

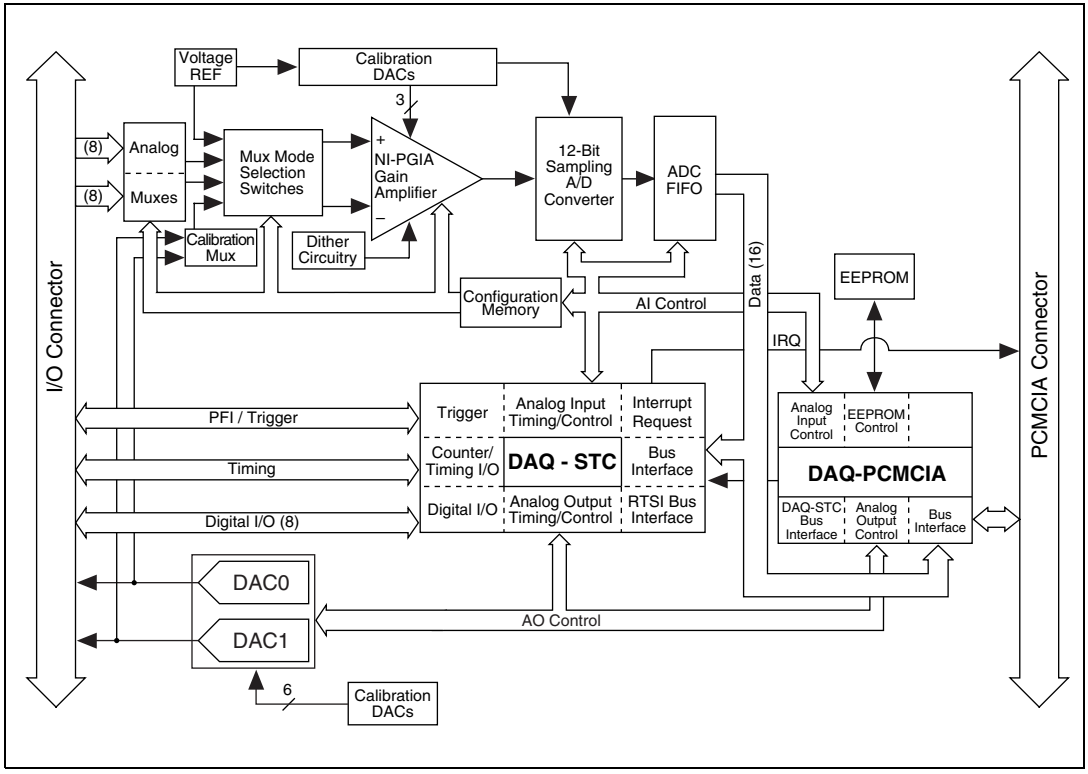


Figure 3-2. DAQCard-6024E Block Diagram

Analog Input

The analog input section of each device is software configurable. The following sections describe in detail each of the analog input settings.

Input Mode

The devices have three different input modes—nonreferenced single-ended (NRSE), referenced single-ended (RSE), and differential (DIFF) input. The single-ended input configurations provide up to 16 channels. The DIFF input configuration provides up to eight channels. Input modes are programmed on a per channel basis for multimode scanning. For example, you can configure the circuitry to scan 12 channels—four DIFF channels and eight RSE channels. Table 3-1 describes the three input configurations.

Table 3-1. Available Input Configurations

Configuration	Description
DIFF	A channel configured in DIFF mode uses two analog input lines. One line connects to the positive input of the programmable gain instrumentation amplifier (PGIA) of the device, and the other connects to the negative input of the PGIA.
RSE	A channel configured in RSE mode uses one analog input line, which connects to the positive input of the PGIA. The negative input of the PGIA is internally tied to analog input ground (AIGND).
NRSE	A channel configured in NRSE mode uses one analog input line, which connects to the positive input of the PGIA. The negative input of the PGIA connects to analog input sense (AISENSE).

For diagrams showing the signal paths of the three configurations, refer to the *Analog Input Signal Overview* section in Chapter 4, *Signal Connections*.

Input Range

The devices have a bipolar input range that changes with the programmed gain. You can program each channel with a unique gain of 0.5, 1.0, 10, or 100 to maximize the 12-bit analog-to-digital converter (ADC) resolution. With the proper gain setting, you can use the full resolution of the ADC to measure the input signal. Table 3-2 shows the input range and precision according to the gain used.

Table 3-2. Measurement Precision

Gain	Input Range	Precision[1]
0.5	–10 to +10 V	4.88 mV
1.0	–5 to +5 V	2.44 mV
10.0	–500 to +500 mV	244.14 µV
100.0	–50 to +50 mV	24.41 µV

[1] The value of 1 LSB of the 12-bit ADC; that is, the voltage increment corresponding to a change of one count in the ADC 12-bit count.

Note: See Appendix A, *Specifications*, for absolute maximum ratings.

Dithering

When you enable dithering, you add approximately 0.5 LSB_{rms} of white Gaussian noise to the signal to be converted by the ADC. This addition is useful for applications involving averaging to increase the resolution of your device, as in calibration or spectral analysis. In such applications, noise modulation is decreased and differential linearity is improved by the addition of dithering. When taking DC measurements, such as when checking the device calibration, enable dithering and average about 1,000 points to take a single reading. This process removes the effects of quantization and reduces measurement noise, resulting in improved resolution. For high-speed applications not involving averaging or spectral analysis, you may want to disable dithering to reduce noise. Your software enables and disables the dithering circuitry.

Figure 3-3 illustrates the effect of dithering on signal acquisition. Figure 3-3a shows a small (±4 LSB) sine wave acquired with dithering off. The ADC quantization is clearly visible. Figure 3-3b shows what happens when 50 such acquisitions are averaged together; quantization is still plainly visible. In Figure 3-3c, the sine wave is acquired with dithering on. There is a considerable amount of visible noise, but averaging about 50 such acquisitions, as shown in Figure 3-3d, eliminates both the added noise and the effects of quantization. Dithering has the effect of forcing quantization noise to become a zero-mean random variable rather than a deterministic function of the input signal.

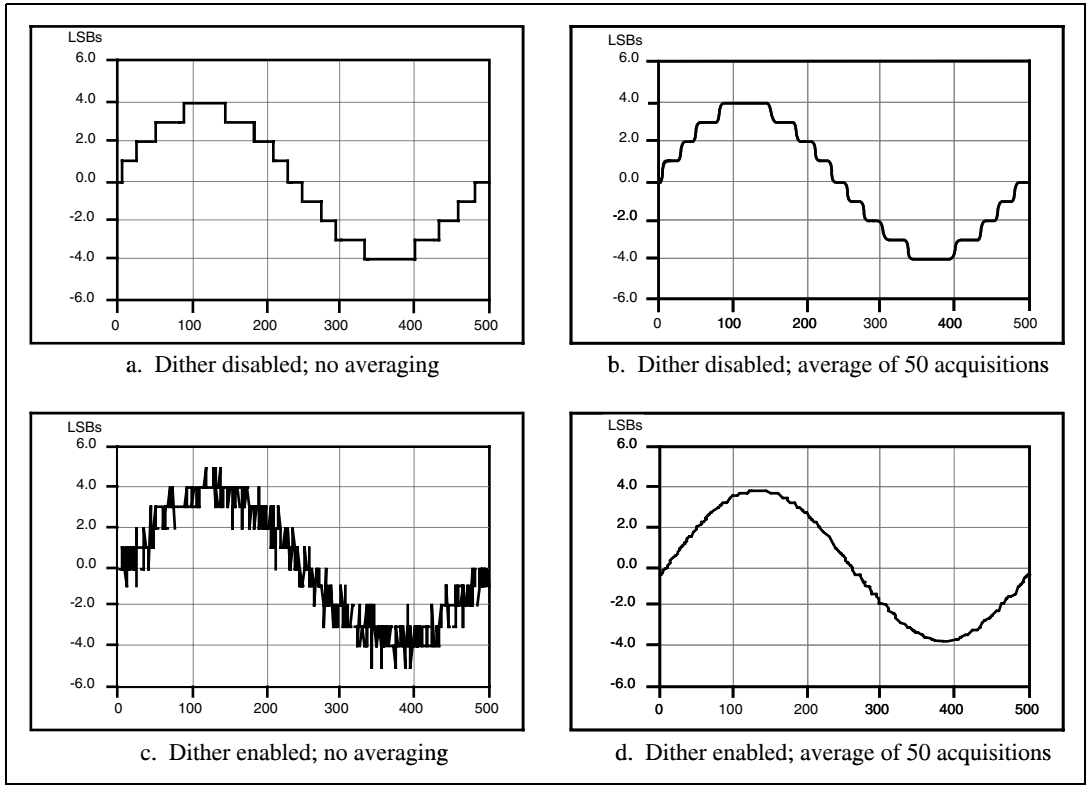


Figure 3-3. Dithering

Multichannel Scanning Considerations

The devices can scan multiple channels at the same maximum rate as their single-channel rate; however, pay careful attention to the settling times for each of the devices. No extra settling time is necessary between channels as long as the gain is constant and source impedances are low. Refer to Appendix A, *Specifications*, for a complete listing of settling times for each of the devices.

When scanning among channels at various gains, the settling times can increase. When the PGIA switches to a higher gain, the signal on the previous channel can be well outside the new, smaller range. For instance, suppose a 4 V signal connects to channel 0 and a 1 mV signal connects to channel 1, and suppose the PGIA is programmed to apply a gain of one to channel 0 and a gain of 100 to channel 1. When the multiplexer switches to channel 1 and the PGIA switches to a gain of 100, the new full-scale range is ±50 mV.

The approximately 4 V step from 4 V to 1 mV is 4,000% of the new full-scale range. It can take as long as 100 µs for the circuitry to settle to 1 LSB after such a large transition. In general, this extra settling time is not needed when the PGIA is switching to a lower gain.

Settling times can also increase when scanning high-impedance signals due to a phenomenon called *charge injection*, where the analog input multiplexer injects a small amount of charge into each signal source when that source is selected. If the impedance of the source is not low enough, the effect of the charge—a voltage error—has not decayed by the time the ADC samples the signal. For this reason, keep source impedances under 1 kΩ to perform high-speed scanning.

Due to the previously described limitations of settling times resulting from these conditions, multiple-channel scanning is not recommended unless sampling rates are low enough or it is necessary to sample several signals as nearly simultaneously as possible. The data is much more accurate and channel-to-channel independent if you acquire data from each channel independently (for example, 100 points from channel 0, then 100 points from channel 1, then 100 points from channel 2, and so on).

Analog Output

- 6025E and 6024E only

These devices supply two channels of analog output voltage at the I/O connector. The bipolar range is fixed at ±10 V. Data written to the digital-to-analog converter (DAC) is interpreted in two's complement format.

Analog Output Glitch

In normal operation, a DAC output glitches whenever it is updated with a new value. The glitch energy differs from code to code and appears as distortion in the frequency spectrum.

Digital I/O

The devices contain eight lines of digital I/O (DIO<0..7>) for general-purpose use. You can individually software-configure each line for either input or output. At system startup and reset, the digital I/O ports are all high impedance.

The hardware up/down control for general-purpose counters 0 and 1 are connected onboard to DIO6 and DIO7, respectively. Thus, you can use DIO6 and DIO7 to control the general-purpose counters. The up/down control signals are input only and do not affect the operation of the DIO lines.

- 6025E only

The 6025E device uses an 82C55A programmable peripheral interface to provide an additional 24 lines of digital I/O that represent three 8-bit ports—PA, PB, PC. You can program each port as an input or output port. The 82C55A has three modes of operation—simple I/O (mode 0), strobed I/O (mode 1), and bidirectional I/O (mode 2). In modes 1 and 2, the three ports are divided into two groups—group A and group B. Each group has eight data bits, plus control and status bits from Port C (PC). Modes 1 and 2 use handshaking signals from the computer to synchronize data transfers. Refer to Chapter 4, *Signal Connections*, for more detailed information.

Timing Signal Routing

The DAQ-STC chip provides a flexible interface for connecting timing signals to other devices or external circuitry. Your device uses the RTSI bus to interconnect timing signals between devices (PCI and PXI buses only), and the programmable function input (PFI) pins on the I/O connector to connect the device to external circuitry. These connections are designed to enable the device to both control and be controlled by other devices and circuits.

There are a total of 13 timing signals internal to the DAQ-STC that you can control by an external source. You can also control these timing signals by signals generated internally to the DAQ-STC, and these selections are fully software-configurable. Figure 3-4 shows an example of the signal routing multiplexer controlling the CONVERT* signal.

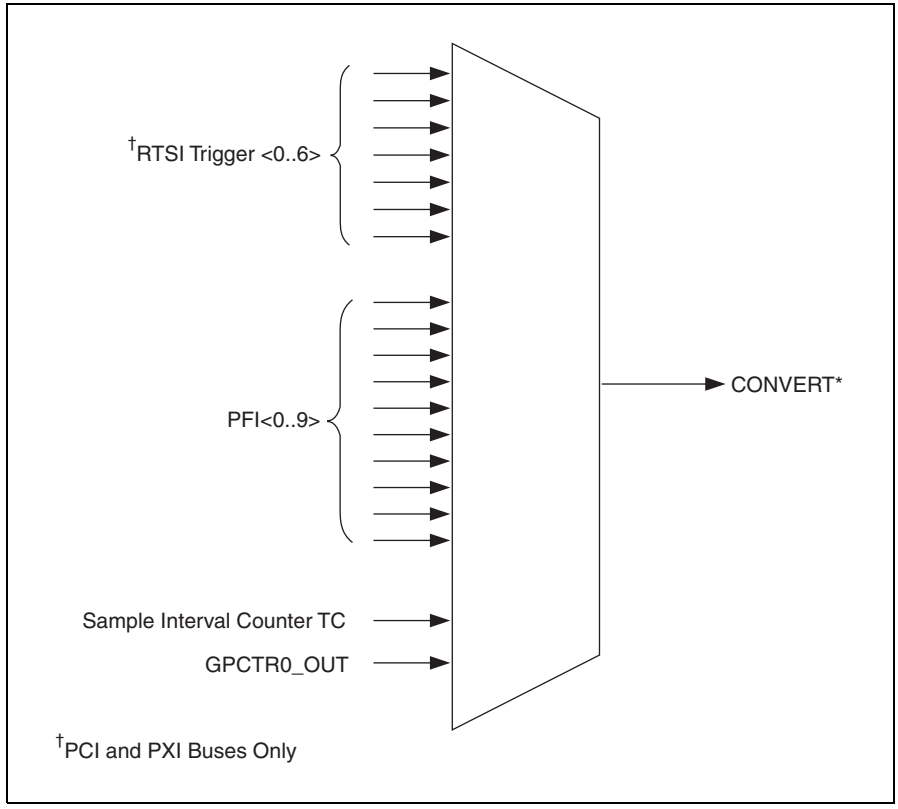


Figure 3-4. CONVERT* Signal Routing

Figure 3-4 shows that CONVERT* can be generated from a number of sources, including the external signals RTSI<0..6> (PCI and PXI buses only) and PFI<0..9> and the internal signals Sample Interval Counter TC and GPCTR0_OUT.

On PCI and PXI devices, many of these timing signals are also available as outputs on the RTSI pins, as indicated in the *RTSI Triggers* section in this chapter, and on the PFI pins, as indicated in Chapter 4, *Signal Connections*.

Programmable Function Inputs

Ten PFI pins are available on the device connector as PFI<0..9> and connect to the internal signal routing multiplexer of the device for each timing signal. Software can select any one of the PFI pins as the external source for a given timing signal. It is important to note that you can use any of the PFI pins as an input by any of the timing signals and that multiple timing signals can use the same PFI simultaneously. This flexible routing

scheme reduces the need to change physical connections to the I/O connector for different applications.

You can also individually enable each of the PFI pins to output a *specific* internal timing signal. For example, if you need the UPDATE* signal as an output on the I/O connector, software can turn on the output driver for the PFI5/UPDATE* pin.

Device and RTSI Clocks

- PCI and PXI buses

  Many device functions require a frequency timebase to generate the necessary timing signals for controlling A/D conversions, DAC updates, or general-purpose signals at the I/O connector.

  These devices can use either its internal 20 MHz timebase or a timebase received over the RTSI bus. In addition, if you configure the device to use the internal timebase, you can also program the device to drive its internal timebase over the RTSI bus to another device that is programmed to receive this timebase signal. This clock source, whether local or from the RTSI bus, is used directly by the device as the primary frequency source. The default configuration at startup is to use the internal timebase without driving the RTSI bus timebase signal. This timebase is software selectable.

- PXI-6025E

  The RTSI clock connects to other devices through the PXI trigger bus on the PXI backplane. The RTSI clock signal uses the PXI trigger <7> line for this connection.

RTSI Triggers

- PCI and PXI buses

  The seven RTSI trigger lines on the RTSI bus provide a very flexible interconnection scheme for any device sharing the RTSI bus. These bidirectional lines can drive any of eight timing signals onto the RTSI bus and can receive any of these timing signals. This signal connection scheme is shown in Figure 3-5 for PCI devices and Figure 3-6 for PXI devices.

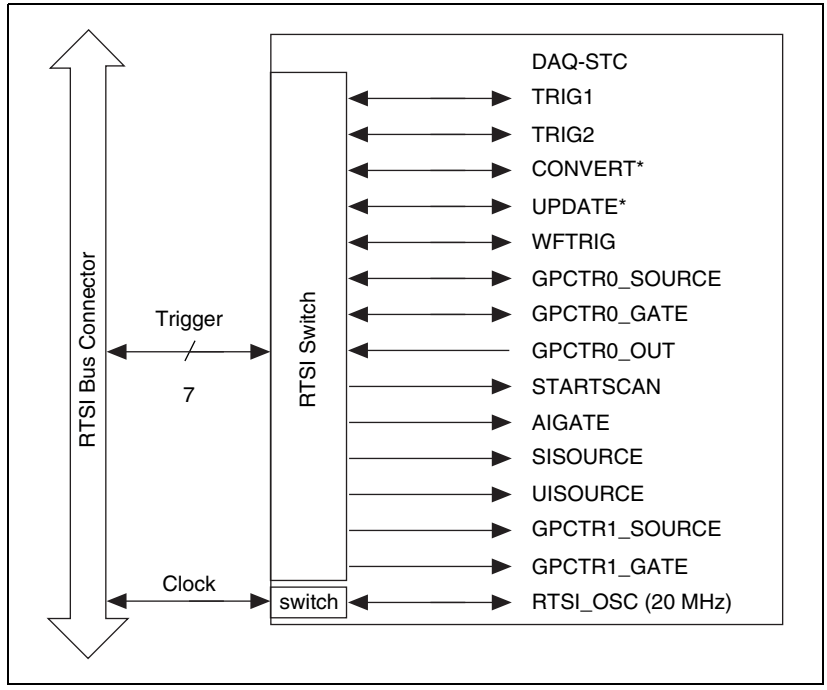


Figure 3-5. PCI RTSI Bus Signal Connection

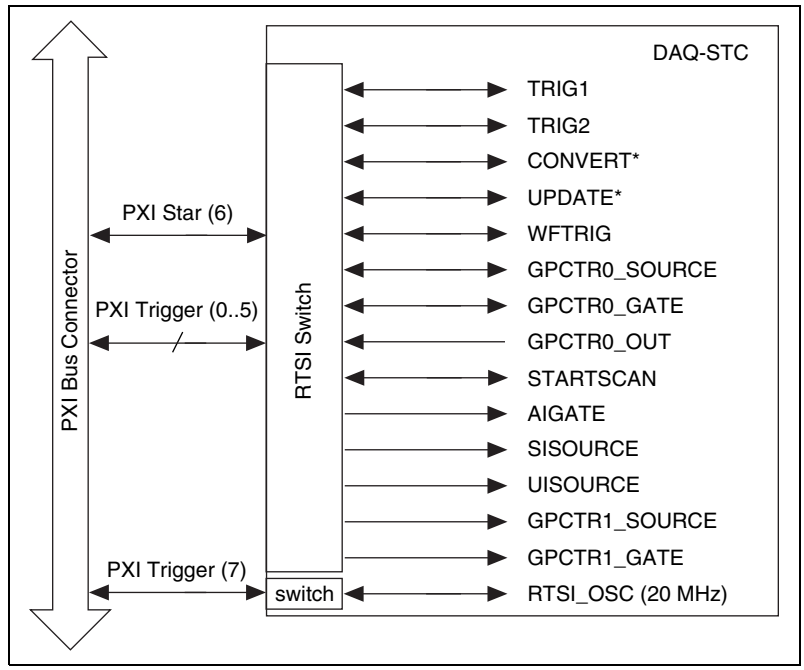


Figure 3-6. PXI RTSI Bus Signal Connection

Table 3-3 lists the name and number of pins used by the PXI-6025E.

Table 3-3. Pins Used by PXI E Series Device

PXI E Series Signal	PXI Pin Name	PXI J2 Pin Number
RTSI<0..5>	PXI Trigger<0..5>	B16, A16, A17, A18, B18, C18
RTSI 6	PXI Star	D17
RTSI Clock	PXI Trigger 7	E16
Reserved	LBL<0..3>	C20, E20, A19, C19
Reserved	LBR<0..12>	A21, C21, D21, E21, A20, B20, E15, A3, C3, D3, E3, A2, B2

Refer to the *Timing Connections* section of Chapter 4, *Signal Connections*, for a description of the signals shown in Figures 3-5 and 3-6.

4

Signal Connections

This chapter describes how to make input and output signal connections to your device through the I/O connector. Table 4-1 shows the cables that can be used with the I/O connectors to connect to different accessories.

Table 4-1. I/O Connector Details

Device with I/O Connector	Number of Pins	Cable for Connecting to 100-pin Accessories	Cable for Connecting to 68-pin Accessories	Cable for Connecting to 50-pin Signal Accessories
PCI-6023E, PCI-6024E	68	N/A	SH6868 Shielded Cable, R6868 Ribbon Cable	SH6850 Shielded Cable, R6850 Ribbon Cable
DAQCard-6024E	68	N/A	SHC68-68EP Shielded Cable, RC68-68 Ribbon Cable	68M-50F Adapter when used with the SHC68-68EP or RC68-68
6025E	100	SH100100 Shielded Cable	SH1006868 Shielded Cable	R1005050 Ribbon Cable

Caution Connections that exceed any of the maximum ratings of input or output signals on the devices can damage the device and the computer. Maximum input ratings for each signal are given in the *Protection* column of Table 4-3. National Instruments is *not* liable for any damages resulting from such signal connections.

I/O Connector

Figure 4-1 shows the pin assignments for the 68-pin I/O connector on the PCI-6023E, PCI-6024E, and DAQCard-6024E. Figure 4-2 shows the pin assignments for the 100-pin I/O connector on the PCI-6025E. Refer to Appendix B, *Custom Cabling and Optional Connectors*, for pin

assignments of the optional 50- and 68-pin connectors. A signal description follows the figures.

ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
DAC0OUT[1]	22	56	AIGND
DAC1OUT[1]	21	55	AOGND
RESERVED	20	54	AOGND
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5 V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5 V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5/UPDATE*	6	40	GPCTR1_OUT
PFI6/WFTRIG	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

[1] Not available on the 6023E

Figure 4-1. I/O Connector Pin Assignment for the 6023E/6024E

AIGND	1	51	PC7
AIGND	2	52	GND
ACH0	3	53	PC6
ACH8	4	54	GND
ACH1	5	55	PC5
ACH9	6	56	GND
ACH2	7	57	PC4
ACH10	8	58	GND
ACH3	9	59	PC3
ACH11	10	60	GND
ACH4	11	61	PC2
ACH12	12	62	GND
ACH5	13	63	PC1
ACH13	14	64	GND
ACH6	15	65	PC0
ACH14	16	66	GND
ACH7	17	67	PB7
ACH15	18	68	GND
AISENSE	19	69	PB6
DAC0OUT	20	70	GND
DAC1OUT	21	71	PB5
RESERVED	22	72	GND
AOGND	23	73	PB4
DGND	24	74	GND
DIO0	25	75	PB3
DIO4	26	76	GND
DIO1	27	77	PB2
DIO5	28	78	GND
DIO2	29	79	PB1
DIO6	30	80	GND
DIO3	31	81	PB0
DIO7	32	82	GND
DGND	33	83	PA7
+5 V	34	84	GND
+5 V	35	85	PA6
SCANCLK	36	86	GND
EXTSTROBE*	37	87	PA5
PFI0/TRIG1	38	88	GND
PFI1/TRIG2	39	89	PA4
PFI2/CONVERT*	40	90	GND
PFI3/GPCTR1_SOURCE	41	91	PA3
PFI4/GPCTR1_GATE	42	92	GND
GPCTR1_OUT	43	93	PA2
PFI5/UPDATE*	44	94	GND
PFI6/WFTRIG	45	95	PA1
PFI7/STARTSCAN	46	96	GND
PFI8/GPCTR0_SOURCE	47	97	PA0
PFI9/GPCTR0_GATE	48	98	GND
GPCTR0_OUT	49	99	+5 V
FREQ_OUT	50	100	GND

Figure 4-2. I/O Connector Pin Assignment for the 6025E

Table 4-2 shows the I/O connector signal descriptions for the 6023E, 6024E, and 6025E.

Table 4-2. I/O Connector Signal Descriptions

Signal Name	Reference	Direction	Description
AIGND	—	—	Analog input ground—these pins are the reference point for single-ended measurements in RSE configuration and the bias current return point for DIFF measurements. All three ground references—AIGND, AOGND, and DGND—are connected on your device.
ACH<0..15>	AIGND	Input	Analog input channels 0 through 15—you can configure each channel pair, ACH<*i*, *i*+8> (*i* = 0..7), as either one DIFF input or two single-ended inputs.
AISENSE	AIGND	Input	Analog input sense—this pin serves as the reference node for any of channels ACH <0..15> in NRSE configuration.
DAC0OUT[1]	AOGND	Output	Analog channel 0 output—this pin supplies the voltage output of analog output channel 0.
DAC1OUT[1]	AOGND	Output	Analog channel 1 output—this pin supplies the voltage output of analog output channel 1.
AOGND	—	—	Analog output ground—the analog output voltages are referenced to this node. All three ground references—AIGND, AOGND, and DGND—are connected together on your device.
DGND	—	—	Digital ground—this pin supplies the reference for the digital signals at the I/O connector as well as the +5 VDC supply. All three ground references—AIGND, AOGND, and DGND—are connected on your device.
DIO<0..7>	DGND	Input or Output	Digital I/O signals—DIO6 and 7 can control the up/down signal of general-purpose counters 0 and 1, respectively.
PA<0..7>[2]	DGND	Input or Output	Port A bidirectional digital data lines for the 82C55A programmable peripheral interface on the 6025E. PA7 is the MSB. PA0 is the LSB.
PB<0..7>[2]	DGND	Input or Output	Port B bidirectional digital data lines for the 82C55A programmable peripheral interface on the 6025E. PB7 is the MSB. PB0 is the LSB.
PC<0..7>[2]	DGND	Input or Output	Port C bidirectional digital data lines for the 82C55A programmable peripheral interface on the 6025E. PC7 is the MSB. PC0 is the LSB.
+5 V	DGND	Output	+5 VDC Source—these pins are fused for up to 1 A of +5 V supply on the PCI and PXI devices, or up to 0.75 A from a DAQCard device. The fuse is self-resetting.

Table 4-2. I/O Connector Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
SCANCLK	DGND	Output	scan clock—this pin pulses once for each A/D conversion in scanning mode when enabled. The low-to-high edge indicates when the input signal can be removed from the input or switched to another signal.
EXTSTROBE*	DGND	Output	External strobe—you can toggle this output under software control to latch signals or trigger events on external devices.
PFI0/TRIG1	DGND	Input Output	PFI0/Trigger 1—as an input, this is one of the programmable function inputs (PFIs). PFI signals are explained in the *Timing Connections* section in this chapter. As an output, this is the TRIG1 (AI start trigger) signal. In posttrigger data acquisition sequences, a low-to-high transition indicates the initiation of the acquisition sequence. In pretrigger applications, a low-to-high transition indicates the initiation of the pretrigger conversions.
PFI1/TRIG2	DGND	Input Output	PFI1/Trigger 2—as an input, this is one of the PFIs. As an output, this is the TRIG2 (AI stop trigger) signal. In pretrigger applications, a low-to-high transition indicates the initiation of the posttrigger conversions. TRIG2 is not used in posttrigger applications.
PFI2/CONVERT*	DGND	Input Output	PFI2/Convert—as an input, this is one of the PFIs. As an output, this is the CONVERT* (AI convert) signal. A high-to-low edge on CONVERT* indicates that an A/D conversion is occurring.
PFI3/GPCTR1_SOURCE	DGND	Input Output	PFI3/Counter 1 Source—as an input, this is one of the PFIs. As an output, this is the GPCTR1_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 1.
PFI4/GPCTR1_GATE	DGND	Input Output	PFI4/Counter 1 Gate—as an input, this is one of the PFIs. As an output, this is the GPCTR1_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 1.
GPCTR1_OUT	DGND	Output	Counter 1 Output—this output is from the general-purpose counter 1 output.

Table 4-2. I/O Connector Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
PFI5/UPDATE*	DGND	Input	PFI5/Update—as an input, this is one of the PFIs.
		Output	As an output, this is the UPDATE* (AO Update) signal. A high-to-low edge on UPDATE* indicates that the analog output primary group is being updated for the 6024E or 6025E.
PFI6/WFTRIG	DGND	Input	PFI6/Waveform Trigger—as an input, this is one of the PFIs.
		Output	As an output, this is the WFTRIG (AO Start Trigger) signal. In timed analog output sequences, a low-to-high transition indicates the initiation of the waveform generation.
PFI7/STARTSCAN	DGND	Input	PFI7/Start of Scan—as an input, this is one of the PFIs.
		Output	As an output, this is the STARTSCAN (AI Scan Start) signal. This pin pulses once at the start of each analog input scan in the interval scan. A low-to-high transition indicates the start of the scan.
PFI8/GPCTR0_SOURCE	DGND	Input	PFI8/Counter 0 Source—as an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR0_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 0.
PFI9/GPCTR0_GATE	DGND	Input	PFI9/Counter 0 Gate—as an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR0_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 0.
GPCTR0_OUT	DGND	Output	Counter 0 Output—this output is from the general-purpose counter 0 output.
FREQ_OUT	DGND	Output	Frequency Output—this output is from the frequency generator output.

* Indicates that the signal is active low

[1] Not available on the 6023E

[2] Not available on the 6023E or 6024E

Table 4-3 shows the I/O signal summary for the 6023E, 6024E, and 6025E.

Table 4-3. I/O Signal Summary

Signal Name	Signal Type and Direction	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
ACH<0..15>	AI	100 GΩ in parallel with 100 pF	42/35	—	—	—	±200 pA
AISENSE	AI	100 GΩ in parallel with 100 pF	40/25	—	—	—	±200 pA
AIGND	AO	—	—	—	—	—	—
DAC0OUT (6024E and 6025E only)	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at -10	10 V/µs	—
DAC1OUT (6024E and 6025E only)	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at -10	10 V/µs	—
AOGND	AO	—	—	—	—	—	—
DGND	DO	—	—	—	—	—	—
VCC	DO	0.1 Ω	Short-circuit to ground	1A fused	—	—	—
DIO<0..7>	DIO	—	V_{cc} +0.5	13 at (V_{cc} -0.4)	24 at 0.4	1.1	50 kΩ pu
PA<0..7> (6025E only)	DIO	—	V_{cc} +0.5	2.5 at 3.7min	2.5 at 0.4	5	100 kΩ pu
PB<0..7> (6025E only)	DIO	—	V_{cc} +0.5	2.5 at 3.7min	2.5 at 0.4	5	100 kΩ pu
PC<0..7> (6025E only)	DIO	—	V_{cc} +0.5	2.5 at 3.7min	2.5 at 0.4	5	100 kΩ pu
SCANCLK	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
EXTSTROBE*	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI0/TRIG1	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI1/TRIG2	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI2/CONVERT*	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI3/GPCTR1_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu

Table 4-3. I/O Signal Summary (Continued)

Signal Name	Signal Type and Direction	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
PFI4/GPCTR1_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR1_OUT	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI5/UPDATE*	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI6/WFTRIG	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI7/STARTSCAN	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI8/GPCTR0_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
PFI9/GPCTR0_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR0_OUT	DO	—	—	3.5 at (V_{cc} -0.4)	5 at 0.4	1.5	50 kΩ pu
FREQ_OUT	DO	—	—	3.5 at (V_{cc}-0.4)	5 at 0.4	1.5	50 kΩ pu

AI = Analog Input DIO = Digital Input/Output pu = pullup
AO = Analog Output DO = Digital Output

Note: The tolerance on the 50 kΩ pullup and pulldown resistors is very large. Actual value can range between 17 kΩ and 100 kΩ

Analog Input Signal Overview

The analog input signals for these devices are ACH<0..15>, ASENSE, and AIGND. Connection of these analog input signals to your device depends on the type of input signal source and the configuration of the analog input channels you are using. This section provides an overview of the different types of signal sources and analog input configuration modes. More specific signal connection information is provided in the *Analog Input Signal Connections* section.

Types of Signal Sources

When configuring the input channels and making signal connections, you must first determine whether the signal sources are floating or ground-referenced.

Floating Signal Sources

A floating signal source is not connected in any way to the building ground system, but has an isolated ground-reference point. Some examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolators, and isolation amplifiers. An instrument or device that has an isolated output is a floating signal source. You must tie the ground reference of a floating signal to the analog input ground of your device to establish a local or onboard reference for the signal. Otherwise, the measured input signal varies as the source floats out of the common-mode input range.

Ground-Referenced Signal Sources

A ground-referenced signal source is connected in some way to the building system ground and is, therefore, already connected to a common ground point with respect to the device, assuming that the computer is plugged into the same power system. Non-isolated outputs of instruments and devices that plug into the building power system fall into this category.

The difference in ground potential between two instruments connected to the same building power system is typically between 1 and 100 mV, but can be much higher if power distribution circuits are not properly connected. If a grounded signal source is improperly measured, this difference can appear as an error in the measurement. The connection instructions for grounded signal sources are designed to eliminate this ground potential difference from the measured signal.

Analog Input Modes

You can configure your device for one of three input modes—nonreferenced single ended (NRSE), referenced single ended (RSE), and differential (DIFF). With the different configurations, you can use the PGIA in different ways. Figure 4-3 shows a diagram of the PGIA of your device.

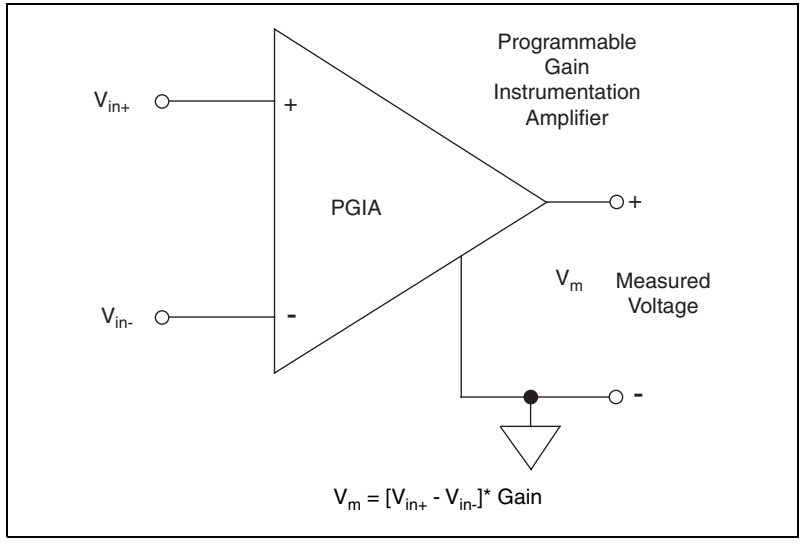


Figure 4-3. Programmable Gain Instrumentation Amplifier (PGIA)

In single-ended mode (RSE and NRSE), signals connected to ACH<0..15> are routed to the positive input of the PGIA. In DIFF mode, signals connected to ACH<0..7> are routed to the positive input of the PGIA, and signals connected to ACH<8..15> are routed to the negative input of the PGIA.

Caution Exceeding the DIFF and common-mode input ranges distorts your input signals. Exceeding the maximum input voltage rating can damage the device and the computer. National Instruments is *not* liable for any damages resulting from such signal connections. The maximum input voltage ratings are listed in the *Protection* column of Table 4-3.

In NRSE mode, the AISENSE signal connects internally to the negative input of the PGIA when their corresponding channels are selected. In DIFF and RSE modes, AISENSE is left unconnected.

AIGND is an analog input common signal that routes directly to the ground connection point on the devices. You can use this signal for a general analog ground connection point to your device if necessary.

The PGIA applies gain and common-mode voltage rejection and presents high input impedance to the analog input signals connected to your device. Signals are routed to the positive and negative inputs of the PGIA through input multiplexers on the device. The PGIA converts two input signals to a signal that is the difference between the two input signals multiplied by the

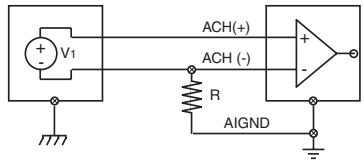
gain setting of the amplifier. The amplifier output voltage is referenced to the ground for the device. The A/D converter (ADC) of your device measures this output voltage when it performs A/D conversions.

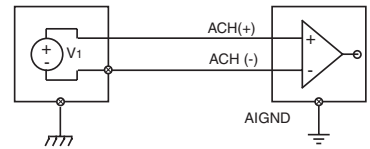
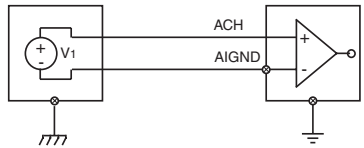
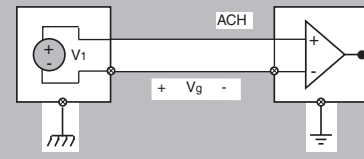
Reference all signals to ground either at the source device or at the device. If you have a floating source, reference the signal to ground by using the RSE input mode or the DIFF input configuration with bias resistors (see the *Differential Connections for Nonreferenced or Floating Signal Sources* section). If you have a grounded source, do not reference the signal to AIGND. You can avoid this reference by using DIFF or NRSE input configurations.

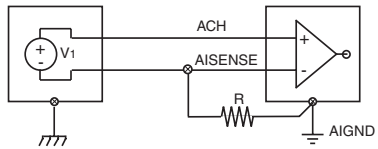
Analog Input Signal Connections

The following sections discuss the use of single-ended and DIFF measurements and recommendations for measuring both floating and ground-referenced signal sources.

Figure 4-4 summarizes the recommended input configuration for both types of signal sources.

<table>
<tr><th rowspan="2">Input</th><th colspan="2">Signal Source Type</th></tr>
<tr><th>Floating Signal Source
(Not Connected to Building Ground)</th><th>Grounded Signal Source</th></tr>
<tr><td></td><td>Examples
• Ungrounded Thermocouples
• Signal conditioning with isolated outputs
• Battery devices</td><td>Examples
• Plug-in instruments with nonisolated outputs</td></tr>
<tr><td>Differential (DIFF)</td><td> 

See text for information on bias resistors.</td><td> 
</td></tr>
<tr><td>Single-Ended — Ground Referenced (RSE)</td><td> 
</td><td>NOT RECOMMENDED
 

Ground-loop losses, V_g, are added to measured signal</td></tr>
<tr><td>Single-Ended — Nonreferenced (NRSE)</td><td> 

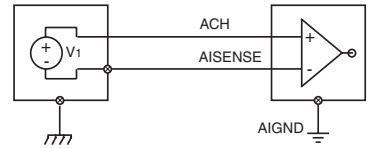
See text for information on bias resistors.</td><td> 
</td></tr>
</table>

Figure 4-4. Summary of Analog Input Connections

Differential Connection Considerations (DIFF Input Configuration)

A DIFF connection is one in which the analog input signal has its own reference signal or signal return path. These connections are available when the selected channel is configured in DIFF input mode. The input signal is connected to the positive input of the PGIA, and its reference signal, or return, is connected to the negative input of the PGIA.

When you configure a channel for DIFF input, each signal uses two multiplexer inputs—one for the signal and one for its reference signal. Therefore, with a DIFF configuration for every channel, up to eight analog input channels are available.

Use DIFF input connections for any channel that meets any of the following conditions:

- The input signal is low level (less than 1 V).
- The leads connecting the signal to the device are greater than 3 m (10 ft).
- The input signal requires a separate ground-reference point or return signal.
- The signal leads travel through noisy environments.

DIFF signal connections reduce picked up noise and increase common-mode noise rejection. DIFF signal connections also allow input signals to float within the common-mode limits of the PGIA.

Differential Connections for Ground-Referenced Signal Sources

Figure 4-5 shows how to connect a ground-referenced signal source to a channel on the device configured in DIFF input mode.

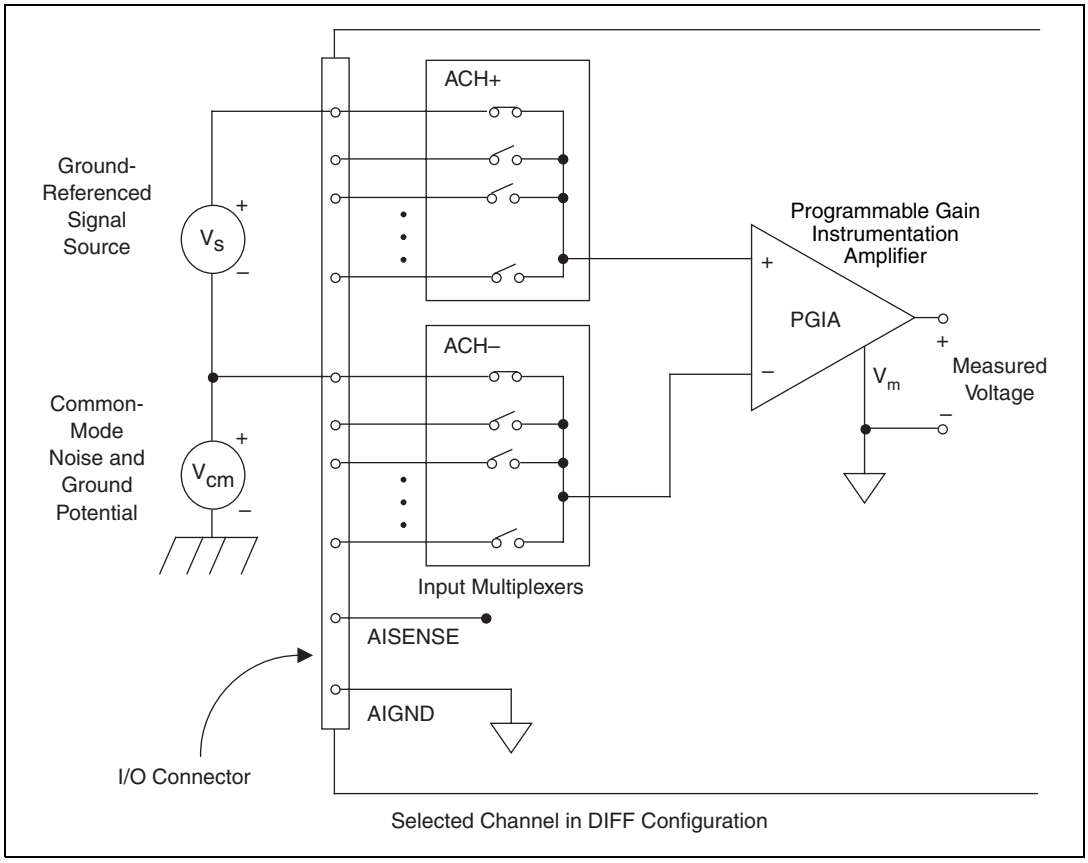


Figure 4-5. Differential Input Connections for Ground-Referenced Signals

With this type of connection, the PGIA rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the device ground, shown as V_{cm} in Figure 4-5.

Differential Connections for Nonreferenced or Floating Signal Sources

Figure 4-6 shows how to connect a floating signal source to a channel configured in DIFF input mode.

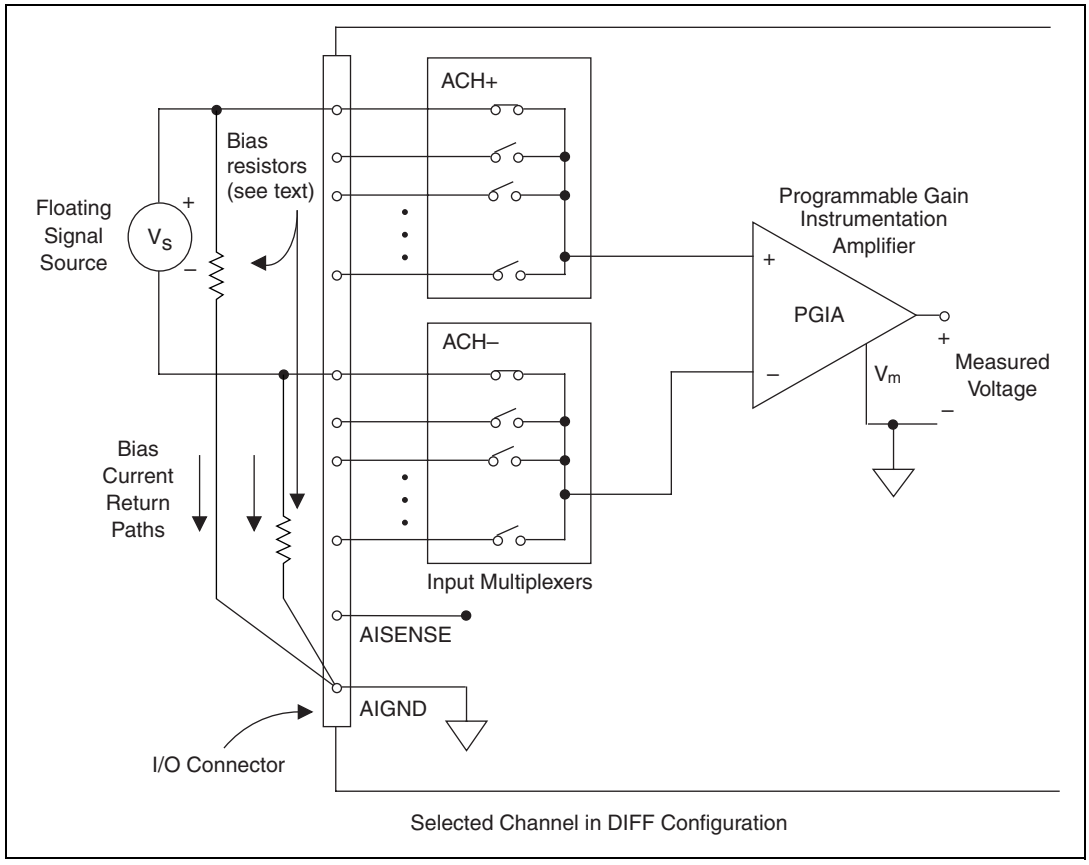


Figure 4-6. Differential Input Connections for Nonreferenced Signals

Figure 4-6 shows two bias resistors connected in parallel with the signal leads of a floating signal source. If you do not use the resistors and the source is truly floating, the source is not likely to remain within the common-mode signal range of the PGIA. The PGIA then saturates, causing erroneous readings.

You must reference the source to AIGND. The easiest way is to connect the positive side of the signal to the positive input of the PGIA and connect the negative side of the signal to AIGND as well as to the negative input of the PGIA, without any resistors at all. This connection works well for DC-coupled sources with low source impedance (less than 100 Ω).

However, for larger source impedances, this connection leaves the DIFF signal path significantly out of balance. Noise that couples electrostatically onto the positive line does not couple onto the negative line because it is connected to ground. Hence, this noise appears as a DIFF-mode signal instead of a common-mode signal, and the PGIA does not reject it. In this case, instead of directly connecting the negative line to AIGND, connect it to AIGND through a resistor that is about 100 times the equivalent source impedance. The resistor puts the signal path nearly in balance, so that about the same amount of noise couples onto both connections, yielding better rejection of electrostatically coupled noise. Also, this configuration does not load down the source (other than the very high input impedance of the PGIA).

You can fully balance the signal path by connecting another resistor of the same value between the positive input and AIGND, as shown in Figure 4-6. This fully balanced configuration offers slightly better noise rejection but has the disadvantage of loading the source down with the series combination (sum) of the two resistors. If, for example, the source impedance is 2 kΩ and each of the two resistors is 100 kΩ, the resistors load down the source with 200 kΩ and produce a –1% gain error.

Both inputs of the PGIA require a DC path to ground in order for the PGIA to work. If the source is AC coupled (capacitively coupled), the PGIA needs a resistor between the positive input and AIGND. If the source has low impedance, choose a resistor that is large enough not to significantly load the source but small enough not to produce significant input offset voltage as a result of input bias current (typically 100 kΩ to 1 MΩ). In this case, you can tie the negative input directly to AIGND. If the source has high output impedance, balance the signal path as previously described using the same value resistor on both the positive and negative inputs; be aware that there is some gain error from loading down the source.

Single-Ended Connection Considerations

A single-ended connection is one in which the device analog input signal is referenced to a ground that it can share with other input signals. The input signal is tied to the positive input of the PGIA, and the ground is tied to the negative input of the PGIA.

When every channel is configured for single-ended input, up to 16 analog input channels are available.

You can use single-ended input connections for any input signal that meets the following conditions:

- The input signal is high level (greater than 1 V).
- The leads connecting the signal to the device are less than 10 ft (3 m).
- The input signal can share a common reference point with other signals.

DIFF input connections are recommended for greater signal integrity for any input signal that does not meet the preceding conditions.

Using your software, you can configure the channels for two different types of single-ended connections—RSE configuration and NRSE configuration. The RSE configuration is used for floating signal sources; in this case, the device provides the reference ground point for the external signal. The NRSE input configuration is used for ground-referenced signal sources; in this case, the external signal supplies its own reference ground point and the device should not supply one.

In single-ended configurations, more electrostatic and magnetic noise couples into the signal connections than in DIFF configurations. The coupling is the result of differences in the signal path. Magnetic coupling is proportional to the area between the two signal conductors. Electrical coupling is a function of how much the electric field differs between the two conductors.

Single-Ended Connections for Floating Signal Sources (RSE Configuration)

Figure 4-7 shows how to connect a floating signal source to a channel configured for RSE mode.

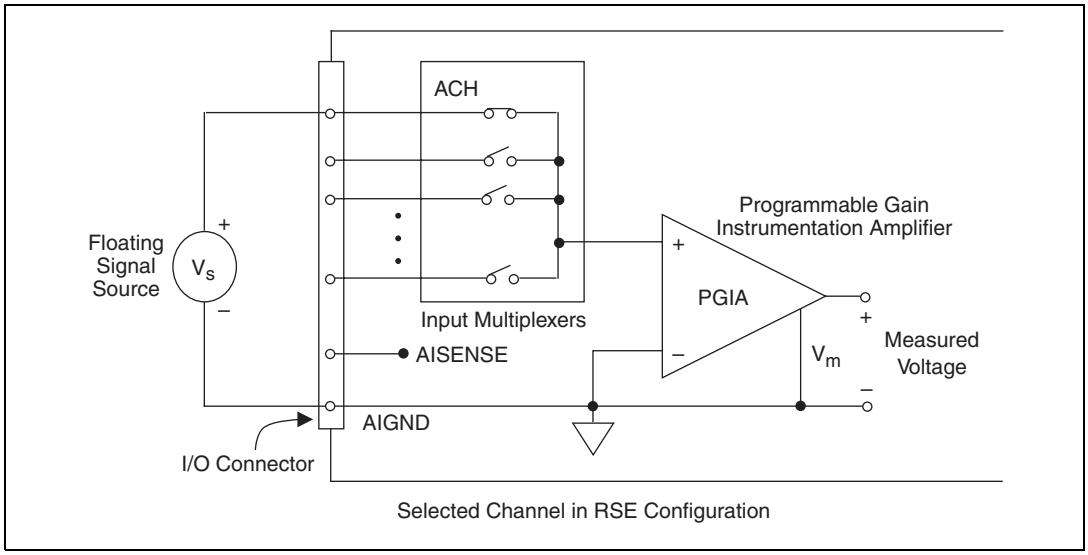


Figure 4-7. Single-Ended Input Connections for Nonreferenced or Floating Signals

Single-Ended Connections for Grounded Signal Sources (NRSE Configuration)

To measure a grounded signal source with a single-ended configuration, you must configure your device in the NRSE input configuration. Connect the signal to the positive input of the PGIA, and connect the signal local ground reference to the negative input of the PGIA. The ground point of the signal, therefore, connects to the AISENSE pin. Any potential difference between the device ground and the signal ground appears as a common-mode signal at both the positive and negative inputs of the PGIA, and this difference is rejected by the amplifier. If the input circuitry of a device were referenced to ground, in this situation as in the RSE input configuration, this difference in ground potentials appears as an error in the measured voltage.

Figure 4-8 shows how to connect a grounded signal source to a channel configured for NRSE mode.

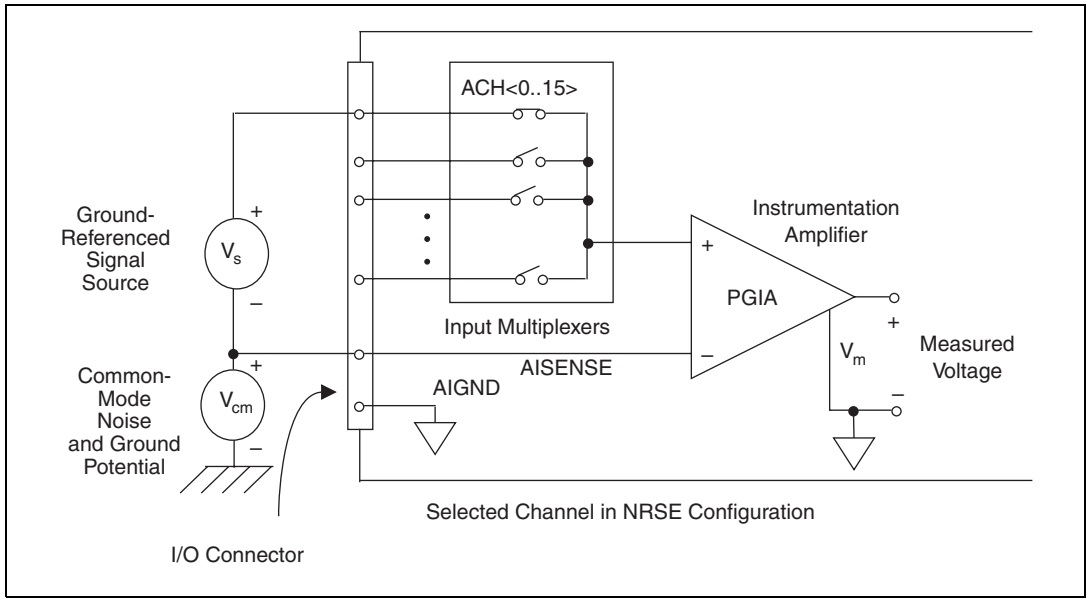


Figure 4-8. Single-Ended Input Connections for Ground-Referenced Signals

Common-Mode Signal Rejection Considerations

Figures 4-5 and 4-8 show connections for signal sources that are already referenced to some ground point with respect to the device. In these cases, the PGIA can reject any voltage caused by ground potential differences between the signal source and the device. In addition, with DIFF input connections, the PGIA can reject common-mode noise pickup in the leads connecting the signal sources to the device. The PGIA can reject common-mode signals as long as $V+_{in}$ and $V-_{in}$ (input signals) are both within ±11 V of AIGND.

Analog Output Signal Connections

- 6024E and 6025E

The analog output signals are DAC0OUT, DAC1OUT, and AOGND. DAC0OUT and DAC1OUT are not available on the 6023E. DAC0OUT is the voltage output signal for analog output channel 0. DAC1OUT is the voltage output signal for analog output channel 1.

AOGND is the ground reference signal for both analog output channels and the external reference signal. Figure 4-9 shows how to make analog output connections to your device.

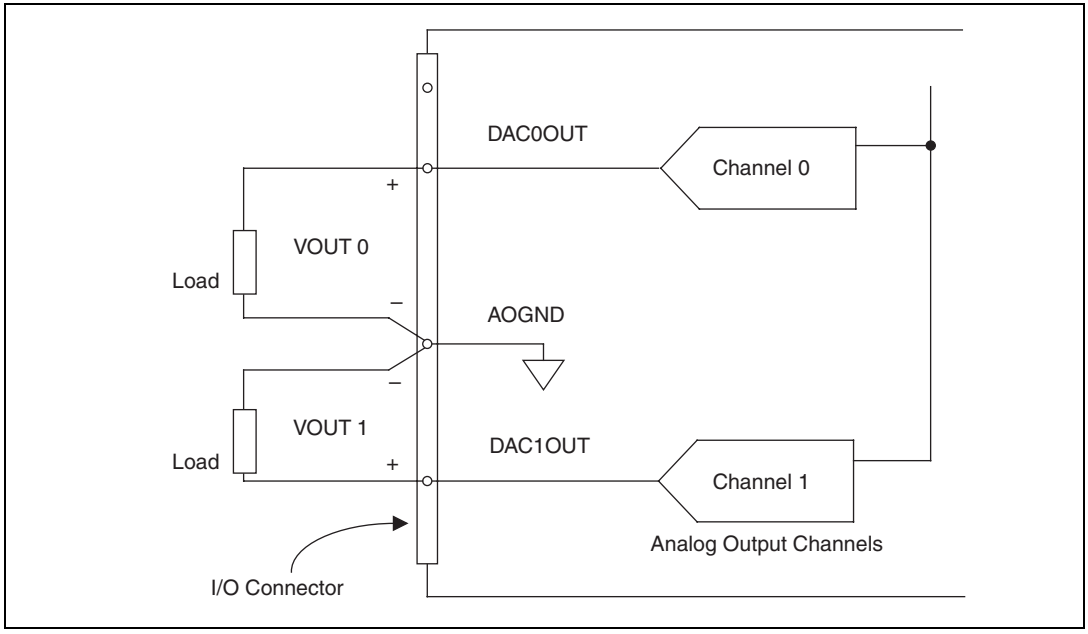


Figure 4-9. Analog Output Connections

Digital I/O Signal Connections

All Devices

All devices have digital I/O signals DIO<0..7> and DGND. DIO<0..7> are the signals making up the DIO port, and DGND is the ground-reference signal for the DIO port. You can program all lines individually as inputs or outputs. Figure 4-10 shows signal connections for three typical digital I/O applications.

Caution Exceeding the maximum input voltage ratings, which are listed in Table 4-2, can damage the DAQ device and the computer. National Instruments is *not* liable for any damages resulting from such signal connections.

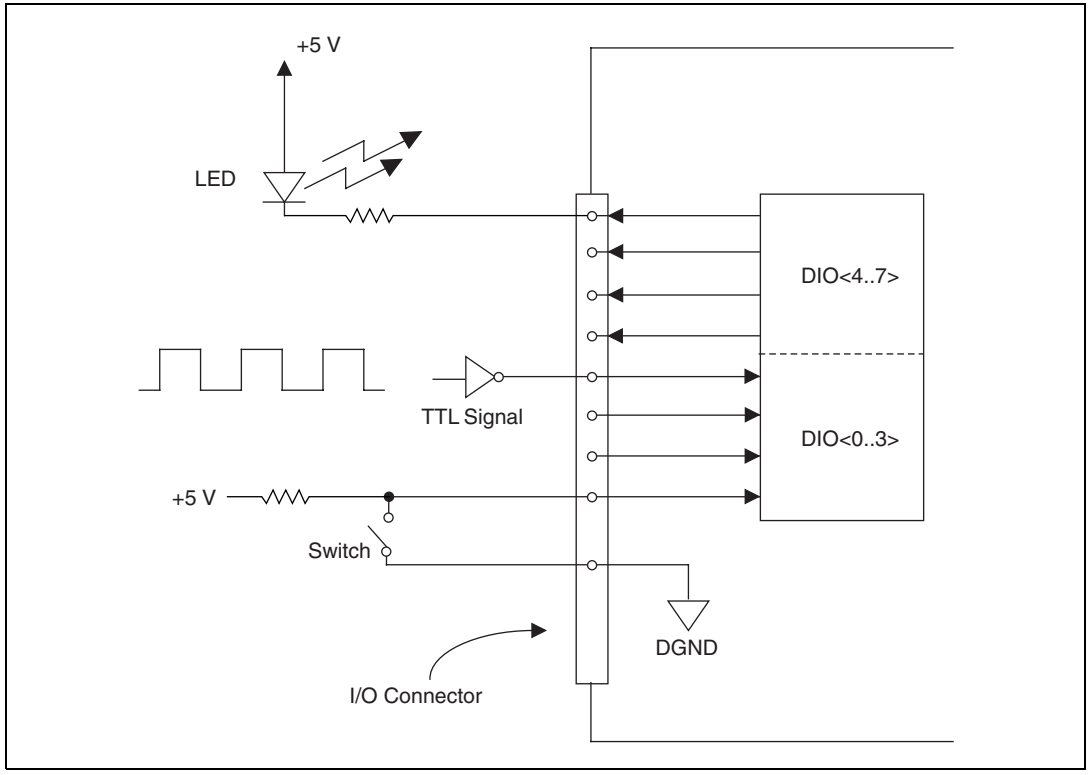


Figure 4-10. Digital I/O Connections

Figure 4-10 shows DIO<0..3> configured for digital input and DIO<4..7> configured for digital output. Digital input applications include receiving TTL signals and sensing external device states such as the state of the switch shown in the Figure 4-11. Digital output applications include sending TTL signals and driving external devices such as the LED shown in Figure 4-11. Figure 4-11 depicts signal connections for three typical digital I/O applications.

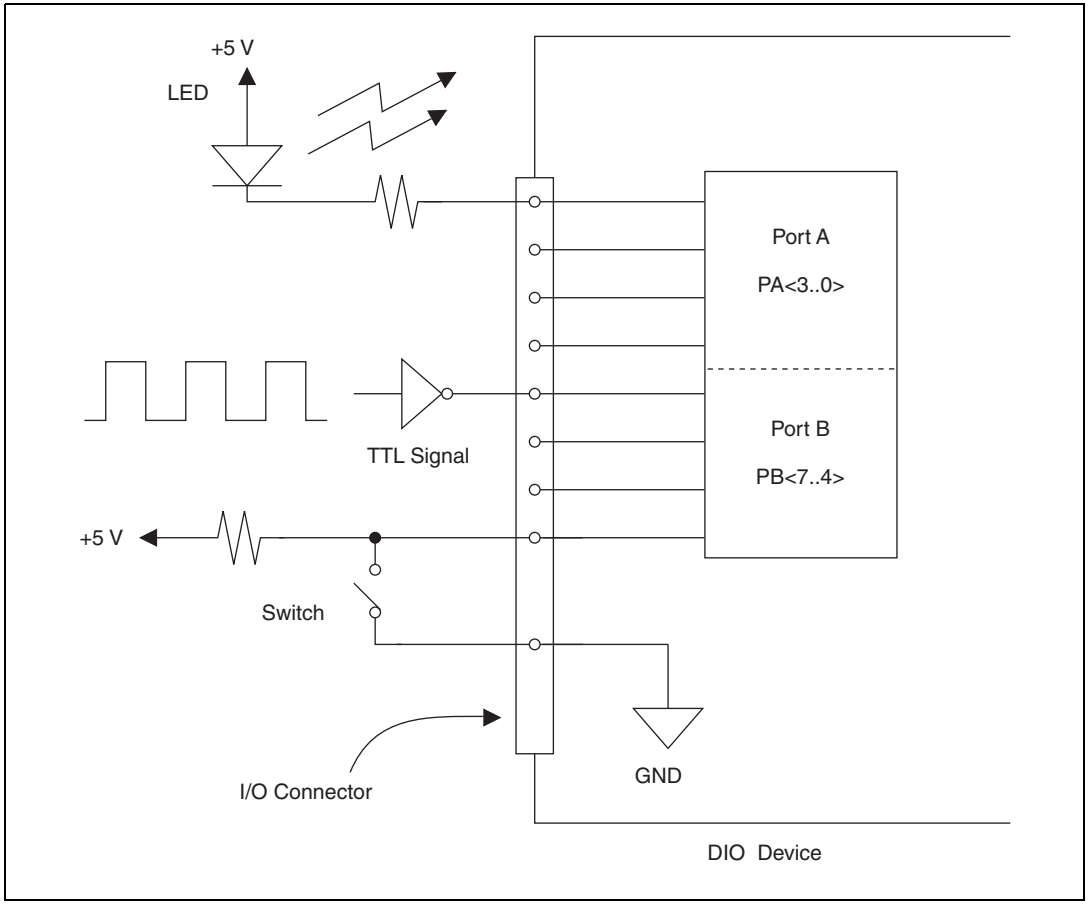


Figure 4-11. Digital I/O Connections Block Diagram

Programmable Peripheral Interface (PPI)

- 6025E only

The 6025E device uses an 82C55A PPI to provide an additional 24 lines of digital I/O that represent three 8-bit ports—PA, PB, and PC. You can program each port as an input or output port.

In Figure 4-11, port A of one PPI is configured for digital output, and port B is configured for digital input. Digital input applications include receiving TTL signals and sensing external device states such as the state of the switch in Figure 4-11. Digital output applications include sending

TTL signals and driving external devices such as the LED shown in Figure 4-11.

Port C Pin Assignments

- 6025 only

The signals assigned to port C depend on how the 82C55A is configured. In mode 0, or no handshaking configuration, port C is configured as two 4-bit I/O ports. In modes 1 and 2, or handshaking configuration, port C is used for status and handshaking signals with any leftover lines available for general-purpose I/O. Table 4-4 summarizes the port C signal assignments for each configuration. You can also use ports A and B in different modes; the table does not show every possible combination.

Note Table 4-4 shows both the port C signal assignments and the terminology correlation between different documentation sources. The 82C55A terminology refers to the different 82C55A configurations as modes, whereas NI-DAQ, ComponentWorks, LabWindows/CVI, and LabVIEW documentation refers to them as handshaking and no handshaking.

Table 4-4. Port C Signal Assignments

Configuration Terminology		Signal Assignments							
6023E/ 6024E/6025E User Manual	**National Instruments Software**	**PC7**	**PC6**	**PC5**	**PC4**	**PC3**	**PC2**	**PC1**	**PC0**
Mode 0 (Basic I/O)	No Handshaking	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O
Mode 1 (Strobed Input)	Handshaking	I/O	I/O	IBF_A	STB_A*	$INTR_A$	STB_B*	$IBFB_B$	$INTR_B$
Mode 1 (Strobed Output)	Handshaking	OBF_A*	ACK_A*	I/O	I/O	$INTR_A$	ACK_B*	OBF_B*	$INTR_B$
Mode 2 (Bidirectional Bus)	Handshaking	OBF_A*	ACK_A*	IBF_A	STB_A*	$INTR_A$	I/O	I/O	I/O

* Indicates that the signal is active low.

Subscripts A and B denote port A or port B handshaking signals.

Power-up State

- 6025E only

The 6025E contains bias resistors that control the state of the digital I/O lines PA<0..7>,PB<0..7>,PC<0..7> at power up. Each digital I/O line is configured as an input, pulled high by a 100 kΩ bias resistor.

You can change individual lines from pulled up to pulled down by adding your own external resistors. This section describes the procedure.

Changing DIO Power-up State to Pulled Low

Each DIO line is pulled to V_{cc} (approximately +5 VDC) with a 100 kΩ resistor. To pull a specific line low, connect between that line and ground a pull-down resistor (R_L) whose value gives you a maximum of 0.4 VDC. The DIO lines provide a maximum of 2.5 mA at 3.7 V in the high state. Using the largest possible resistor ensures that you do not use more current than necessary to perform the pull-down task.

However, make sure the value of the resistor is not so large that leakage current from the DIO line along with the current from the 100 kΩ pull-up resistor drives the voltage at the resistor above a TTL-low level of 0.4 VDC. Figure 4-12 shows the DIO configuration for high DIO power-up state.

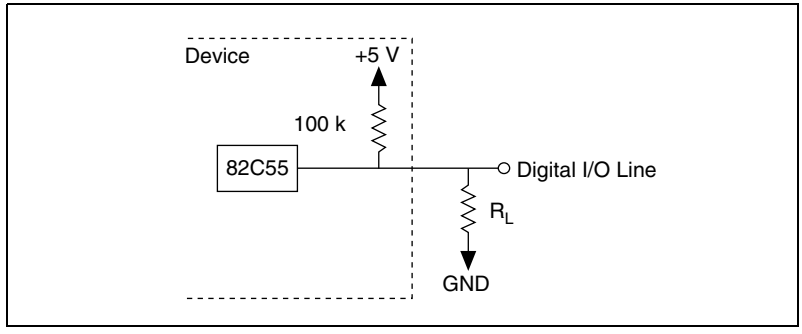


Figure 4-12. DIO Channel Configured for High DIO Power-up State with External Load

Example

A given DIO line is pulled high at power up. To pull it low on power up with an external resistor, follow these steps:

1. Install a load (R_L). Remember that the smaller the resistance, the greater the current consumption and the lower the voltage.

2. Using the following formula, calculate the largest possible load to maintain a logic low level of 0.4 V and supply the maximum driving current:

   $V = I \times RL \Rightarrow RL = V/I$

   where:

V = 0.4 V	Voltage across RL
I = 46 µA + 10 µA	4.6 V across the 100 kΩ pull-up resistor and 10 µA maximum leakage current

   Therefore:

RL = 7.1 kΩ	; 0.4 V/56 µA

This resistor value, 7.1 kΩ, provides a maximum of 0.4 V on the DIO line at power up. You can substitute smaller resistor values to lower the voltage or to provide a margin for V_{cc} variations and other factors. However, smaller values draw more current, leaving less drive current for other circuitry connected to this line. The 7.1 kΩ resistor reduces the amount of logic high source current by 0.4 mA with a 2.8 V output.

Timing Specifications

- 6025E only

This section lists the timing specifications for handshaking with your 6025E PC<0..7> lines. The handshaking lines STB* and IBF synchronize input transfers. The handshaking lines OBF* and ACK* synchronize output transfers. Table 4-5 describes signals appearing in the handshaking diagrams.

Table 4-5. Signal Names Used in Timing Diagrams

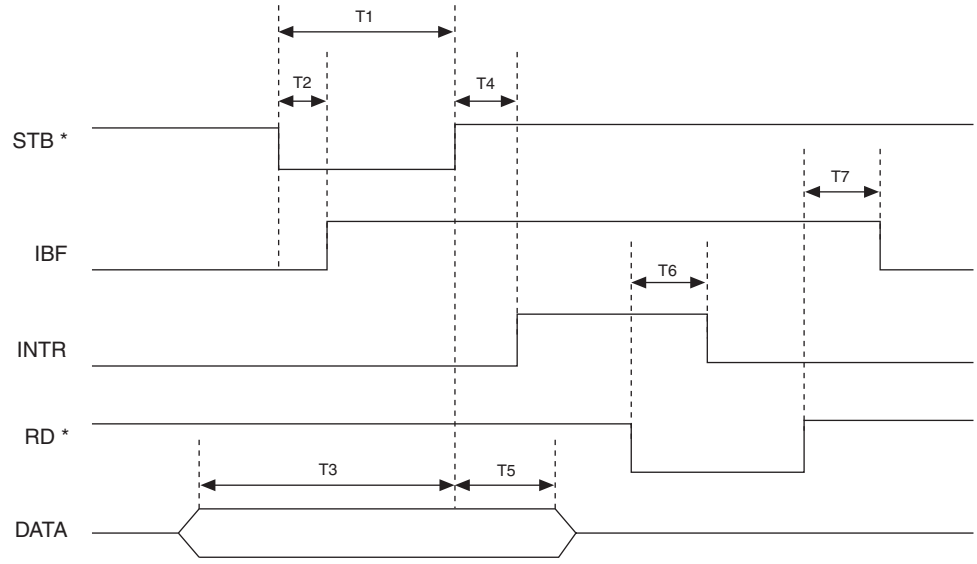
Name	Type	Description
STB*	Input	Strobe input—a low signal on this handshaking line loads data into the input latch.
IBF	Output	Input buffer full—a high signal on this handshaking line indicates that data has been loaded into the input latch. A low signal indicates the device is ready for more data. This is an input acknowledge signal.

Table 4-5. Signal Names Used in Timing Diagrams (Continued)

Name	Type	Description
ACK*	Input	Acknowledge input—a low signal on this handshaking line indicates that the data written to the port has been accepted. This signal is a response from the external device indicating that it has received the data from your DIO device.
OBF*	Output	Output buffer full—a low signal on this handshaking line indicates that data has been written to the port.
INTR	Output	Interrupt request—this signal becomes high when the 82C55A requests service during a data transfer. You must set the appropriate interrupt enable bits to generate this signal.
RD*	Internal	Read—this signal is the read signal generated from the control lines of the computer I/O expansion bus.
WR*	Internal	Write—this signal is the write signal generated from the control lines of the computer I/O expansion bus.
DATA	Bidirectional	Data lines at the specified port—for output mode, this signal indicates the availability of data on the data line. For input mode, this signal indicates when the data on the data lines should be valid.

Mode 1 Input Timing

Timing specifications for an input transfer in mode 1 are shown in Figure 4-13.



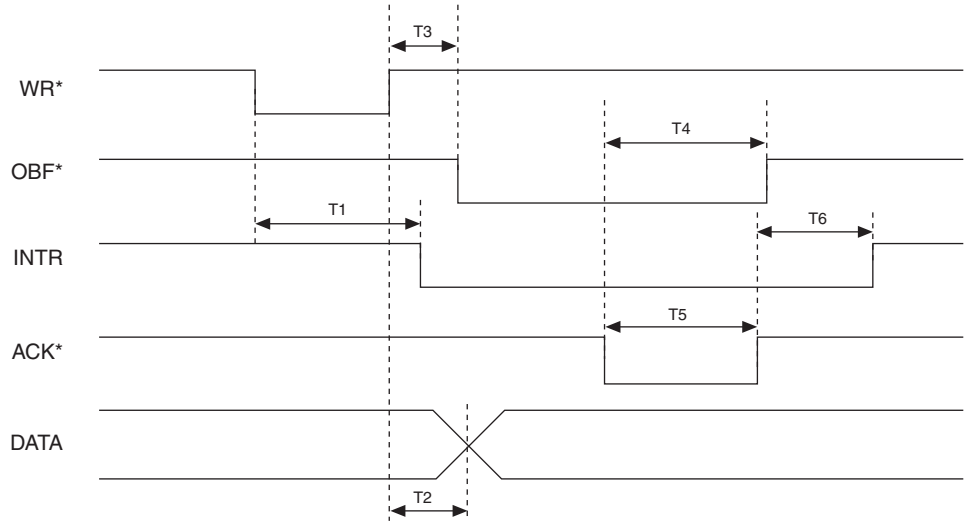
Name	Description	Minimum	Maximum
T1	STB* Pulse Width	100	—
T2	STB* = 0 to IBF = 1	—	150
T3	Data before STB* = 1	20	—
T4	STB* = 1 to INTR = 1	—	150
T5	Data after STB* = 1	50	—
T6	RD* = 0 to INTR = 0	—	200
T7	RD* = 1 to IBF = 0	—	150

All timing values are in nanoseconds.

Figure 4-13. Timing Specifications for Mode 1 Input Transfer

Mode 1 Output Timing

Timing specifications for an output transfer in mode 1 are shown in Figure 4-14.



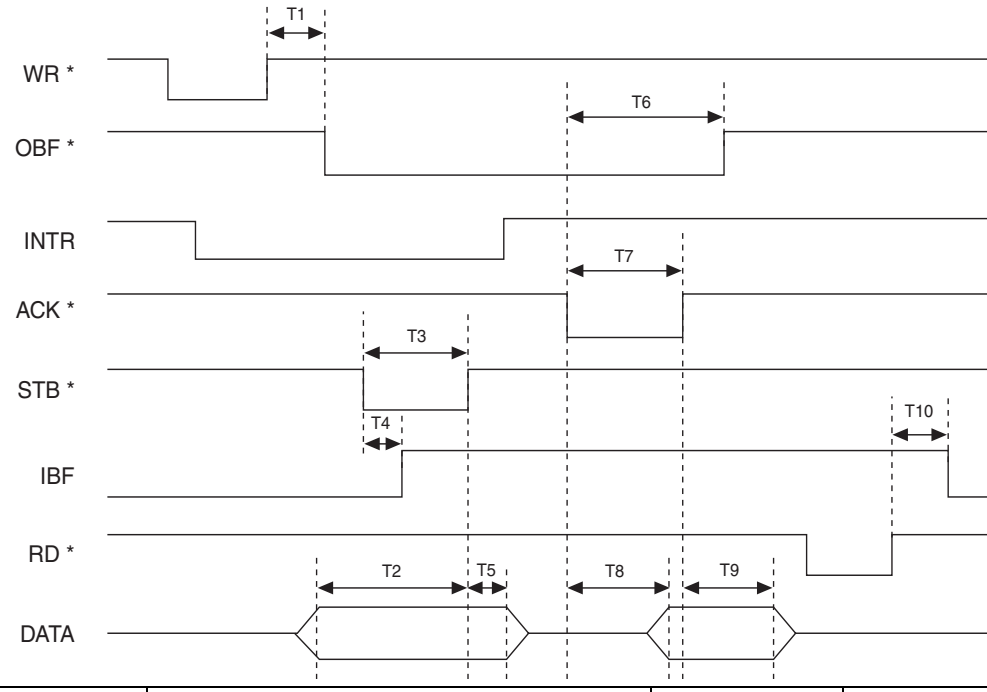
Name	Description	Minimum	Maximum
T1	WR* = 0 to INTR = 0	—	250
T2	WR* = 1 to Output	—	200
T3	WR* = 1 to OBF* = 0	—	150
T4	ACK* = 0 to OBF* = 1	—	150
T5	ACK* Pulse Width	100	—
T6	ACK* = 1 to INTR = 1	—	150

All timing values are in nanoseconds.

Figure 4-14. Timing Specifications for Mode 1 Output Transfer

Mode 2 Bidirectional Timing

Timing specifications for a bidirectional transfer in mode 2 are shown in Figure 4-15.



Name	Description	Minimum	Maximum
T1	WR* = 1 to OBF* = 0	—	150
T2	Data before STB* = 1	20	—
T3	STB* Pulse Width	100	—
T4	STB* = 0 to IBF = 1	—	150
T5	Data after STB* = 1	50	—
T6	ACK* = 0 to OBF* = 1	—	150
T7	ACK* Pulse Width	100	—
T8	ACK* = 0 to Output	—	150
T9	ACK* = 1 to Output Float	20	250
T10	RD* = 1 to IBF = 0	—	150

All timing values are in nanoseconds.

Figure 4-15. Timing Specifications for Mode 2 Bidirectional Transfer

Power Connections

Two pins on the I/0 connector supply +5 V from the computer power supply through a self-resetting fuse. The fuse resets automatically within a few seconds after the overcurrent condition is removed. These pins are referenced to DGND and you can use them to power external digital circuitry. The power rating is +4.65 to +5.25 VDC at 1 A for the PCI and PXI devices, and +4.65 to +5.25 VDC at 0.75A for PCMCIA cards.

Caution Under no circumstances connect these +5 V power pins directly to analog or digital grounds, or to any other voltage source on the device or any other device. Doing so can damage the device and the computer. National Instruments is *not* liable for damages resulting from such a connection.

Timing Connections

Caution Exceeding the maximum input voltage ratings, which are listed in Table 4-3, can damage the device and the computer. National Instruments is *not* liable for any damages resulting from such signal connections.

All external control over the timing of your device is routed through the 10 programmable function inputs labeled PFI<0..9>. These signals are explained in detail in the *Programmable Function Input Connections* section. These PFIs are bidirectional; as outputs they are not programmable and reflect the state of many DAQ, waveform generation, and general-purpose timing signals. There are five other dedicated outputs for the remainder of the timing signals. As inputs, the PFI signals are programmable and can control any DAQ, waveform generation, and general-purpose timing signals.

The DAQ signals are explained in the *DAQ Timing Connections* section; the waveform generation signals in the *Waveform Generation Timing Connections* section, and the general-purpose timing signals in the *General-Purpose Timing Signal Connections* section.

All digital timing connections are referenced to DGND. This reference is demonstrated in Figure 4-16, which shows how to connect an external TRIG1 source and an external CONVERT* source to two PFI pins.

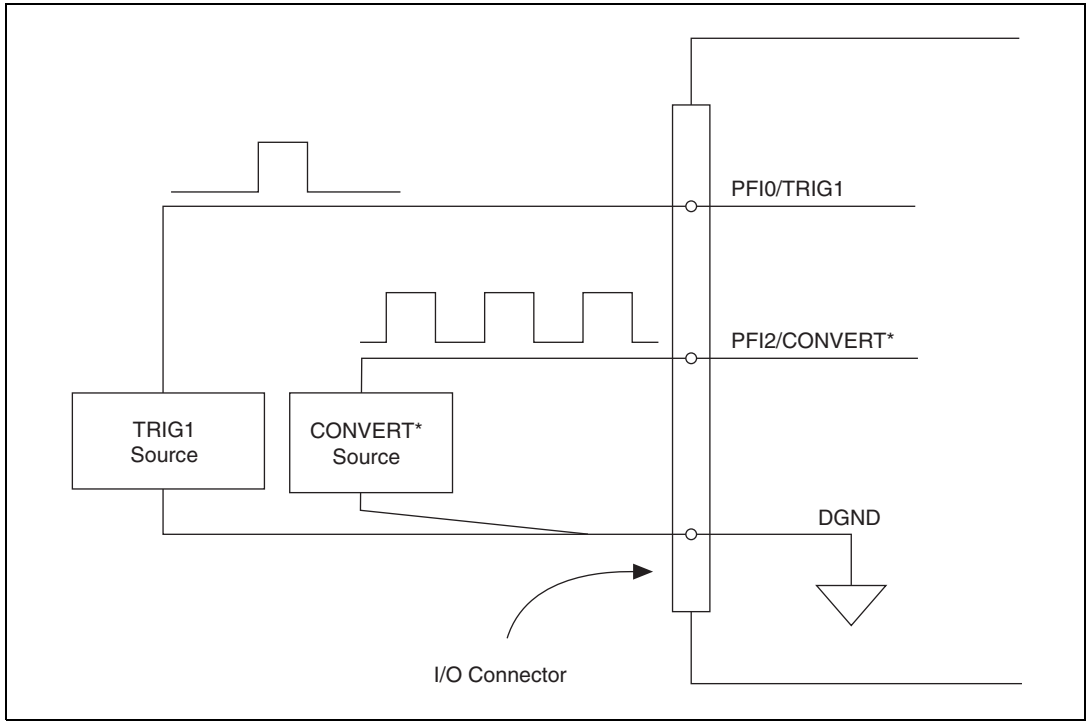


Figure 4-16. Timing I/O Connections

Programmable Function Input Connections

There are a total of 13 internal timing signals that you can externally control from the PFI pins. The source for each of these signals is software-selectable from any of the PFIs when you want external control. This flexible routing scheme reduces the need to change the physical wiring to the device I/O connector for different applications requiring alternative wiring.

You can individually enable each of the PFI pins to output a specific internal timing signal. For example, if you need the CONVERT* signal as an output on the I/O connector, software can turn on the output driver for the PFI2/CONVERT* pin. Be careful not to drive a PFI signal externally when it is configured as an output.

As an input, you can individually configure each PFI pin for edge or level detection and for polarity selection, as well. You can use the polarity selection for any of the 13 timing signals, but the edge or level detection

depends upon the particular timing signal you are controlling. The detection requirements for each timing signal are listed within the section that discusses that individual signal.

In edge-detection mode, the minimum pulse width required is 10 ns. This applies for both rising-edge and falling-edge polarity settings. There is no maximum pulse-width requirement in edge-detect mode.

In level-detection mode, there are no minimum or maximum pulse-width requirements imposed by the PFIs themselves, but there can be limits imposed by the particular timing signal that is controlled. These requirements are listed in this chapter under the section for each applicable signal.

DAQ Timing Connections

The DAQ timing signals are SCANCLK, EXTSTROBE*, TRIG1, TRIG2, STARTSCAN, CONVERT*, AIGATE, and SISOURCE.

Posttriggered data acquisition allows you to view only data that is acquired after a trigger event is received. A typical posttriggered DAQ sequence is shown in Figure 4-17. Pretriggered data acquisition allows you to view data that is acquired before the trigger of interest in addition to data acquired after the trigger. Figure 4-18 shows a typical pretriggered DAQ sequence. The description for each signal shown in these figures is included in this chapter under the section for each corresponding signal.

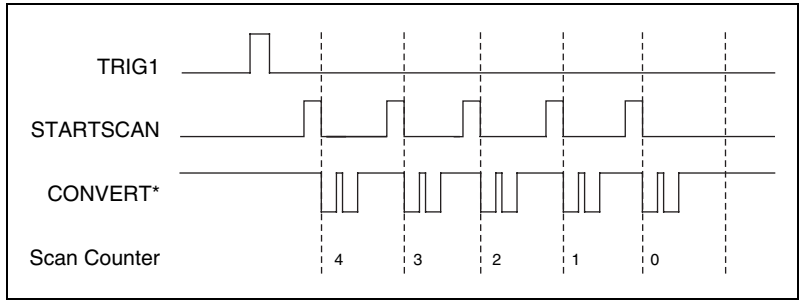


Figure 4-17. Typical Posttriggered Acquisition

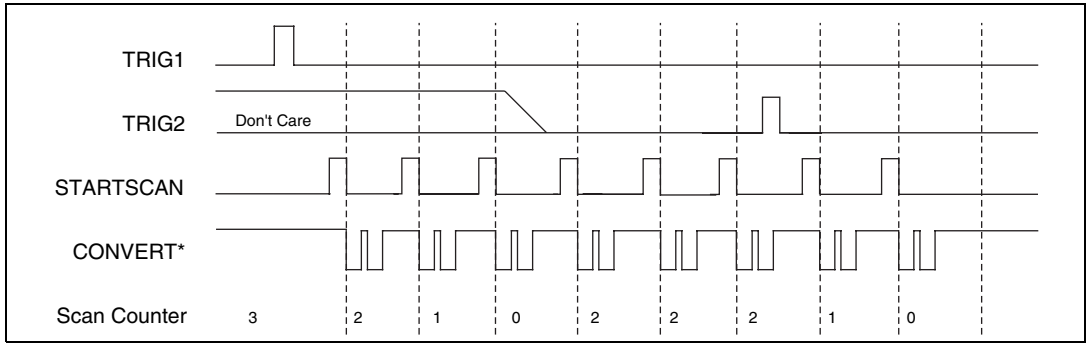


Figure 4-18. Typical Pretriggered Acquisition

SCANCLK Signal

SCANCLK is an output-only signal that generates a pulse with the leading edge occurring approximately 50 to 100 ns after an A/D conversion begins. The polarity of this output is software-selectable, but is typically configured so that a low-to-high leading edge can clock external analog input multiplexers indicating when the input signal has been sampled and can be removed. This signal has a 400 to 500 ns pulse width and is software-enabled. Figure 4-19 shows the timing for the SCANCLK signal.

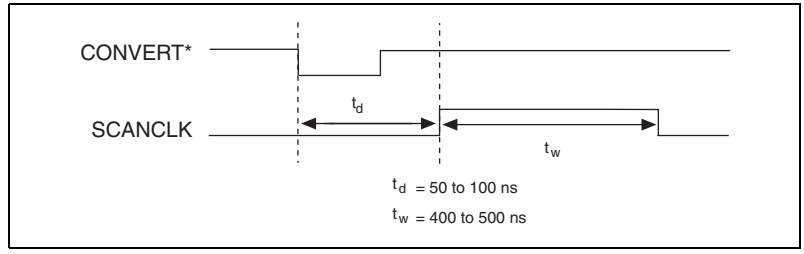


Figure 4-19. SCANCLK Signal Timing

EXTSTROBE* Signal

EXTSTROBE* is an output-only signal that generates either a single pulse or a sequence of eight pulses in the hardware-strobe mode. An external device can use this signal to latch signals or to trigger events. In the single-pulse mode, software controls the level of the EXTSTROBE* signal. A 10 µs and a 1.2 µs clock are available for generating a sequence of eight pulses in the hardware-strobe mode. Figure 4-20 shows the timing for the hardware-strobe mode EXTSTROBE* signal.

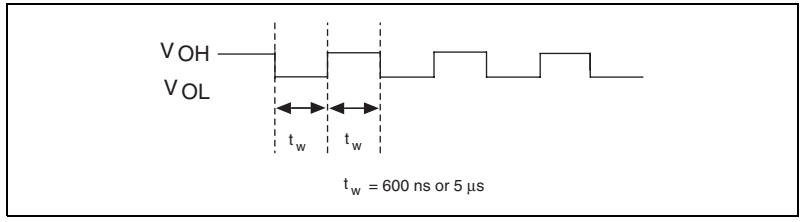


Figure 4-20. EXTSTROBE* Signal Timing

TRIG1 Signal

Any PFI pin can externally input the TRIG1 signal, which is available as an output on the PFI0/TRIG1 pin.

Refer to Figures 4-17 and 4-18 for the relationship of TRIG1 to the DAQ sequence.

As an input, the TRIG1 signal is configured in the edge-detection mode. You can select any PFI pin as the source for TRIG1 and configure the polarity selection for either rising or falling edge. The selected edge of the TRIG1 signal starts the data acquisition sequence for both posttriggered and pretriggered acquisitions.

As an output, the TRIG1 signal reflects the action that initiates a DAQ sequence. This is true even if the acquisition is externally triggered by another PFI. The output is an active high pulse with a pulse width of 50 to 100 ns. This output is set to high impedance at startup.

Figures 4-21 and 4-22 show the input and output timing requirements for the TRIG1 signal.

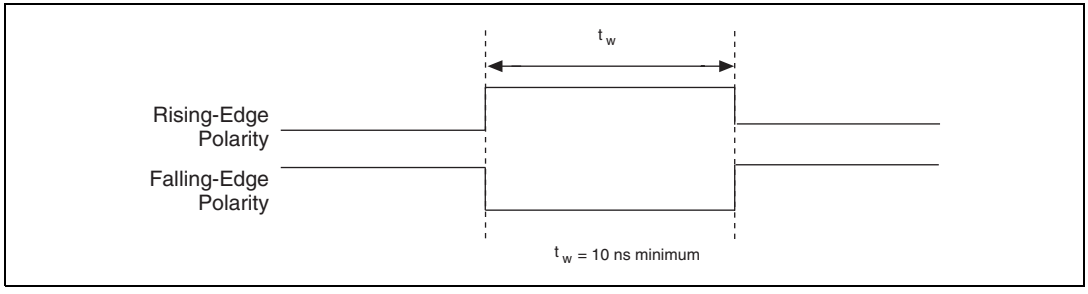


Figure 4-21. TRIG1 Input Signal Timing

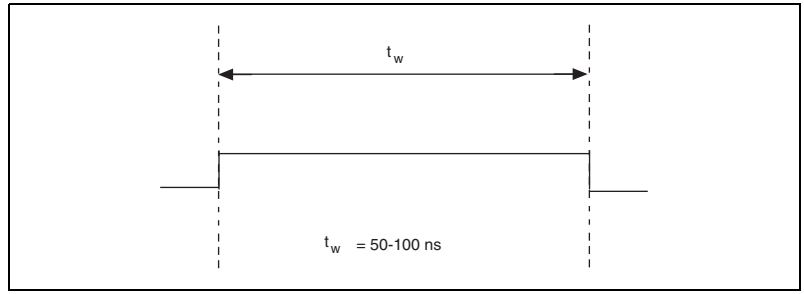


Figure 4-22. TRIG1 Output Signal Timing

The device also uses the TRIG1 signal to initiate pretriggered DAQ operations. In most pretriggered applications, the TRIG1 signal is generated by a software trigger. Refer to the TRIG2 signal description for a complete description of the use of TRIG1 and TRIG2 in a pretriggered DAQ operation.

TRIG2 Signal

Any PFI pin can externally input the TRIG2 signal, which is available as an output on the PFI1/TRIG2 pin. Refer to Figure 4-18 for the relationship of TRIG2 to the DAQ sequence.

As an input, the TRIG2 signal is configured in the edge-detection mode. You can select any PFI pin as the source for TRIG2 and configure the polarity selection for either rising or falling edge. The selected edge of the TRIG2 signal initiates the posttriggered phase of a pretriggered acquisition sequence. In pretriggered mode, the TRIG1 signal initiates the data acquisition. The scan counter indicates the minimum number of scans before TRIG2 can be recognized. After the scan counter decrements to zero, it is loaded with the number of posttrigger scans to acquire while the acquisition continues. The device ignores the TRIG2 signal if it is asserted prior to the scan counter decrementing to zero. After the selected edge of TRIG2 is received, the device acquires a fixed number of scans and the acquisition stops. This mode acquires data both before and after receiving TRIG2.

As an output, the TRIG2 signal reflects the posttrigger in a pretriggered acquisition sequence. This is true even if the acquisition is externally triggered by another PFI. The TRIG2 signal is not used in posttriggered data acquisition. The output is an active high pulse with a pulse width of 50 to 100 ns. This output is set to high impedance at startup.

Figures 4-23 and 4-24 show the input and output timing requirements for the TRIG2 signal.

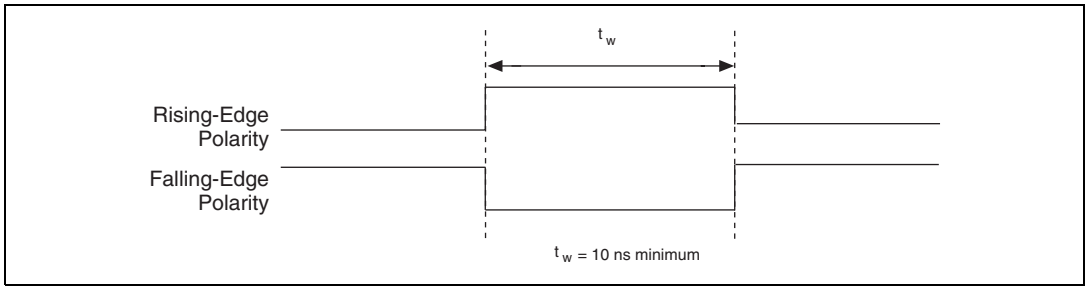


Figure 4-23. TRIG2 Input Signal Timing

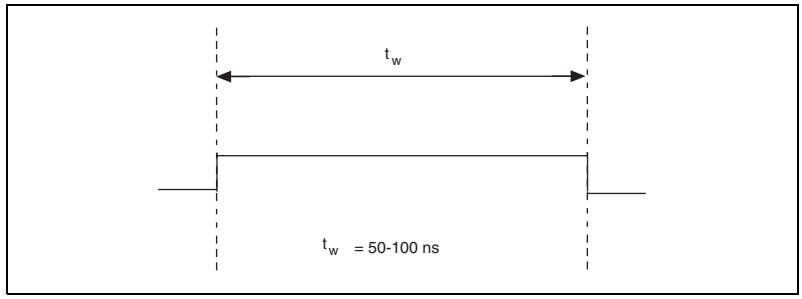


Figure 4-24. TRIG2 Output Signal Timing

STARTSCAN Signal

Any PFI pin can externally input the STARTSCAN signal, which is available as an output on the PFI7/STARTSCAN pin. Refer to Figures 4-17 and 4-18 for the relationship of STARTSCAN to the DAQ sequence.

As an input, the STARTSCAN signal is configured in the edge-detection mode. You can select any PFI pin as the source for STARTSCAN and configure the polarity selection for either rising or falling edge. The selected edge of the STARTSCAN signal initiates a scan. The sample interval counter starts if you select internally triggered CONVERT*.

As an output, the STARTSCAN signal reflects the actual start pulse that initiates a scan. This is true even if the starts are externally triggered by another PFI. You have two output options. The first is an active high pulse with a pulse width of 50 to 100 ns, which indicates the start of the scan. The second action is an active high pulse that terminates at the start of the last conversion in the scan, which indicates a scan in progress. STARTSCAN is

deasserted t_{off} after the last conversion in the scan is initiated. This output is set to high impedance at startup.

Figures 4-25 and 4-26 show the input and output timing requirements for the STARTSCAN signal.

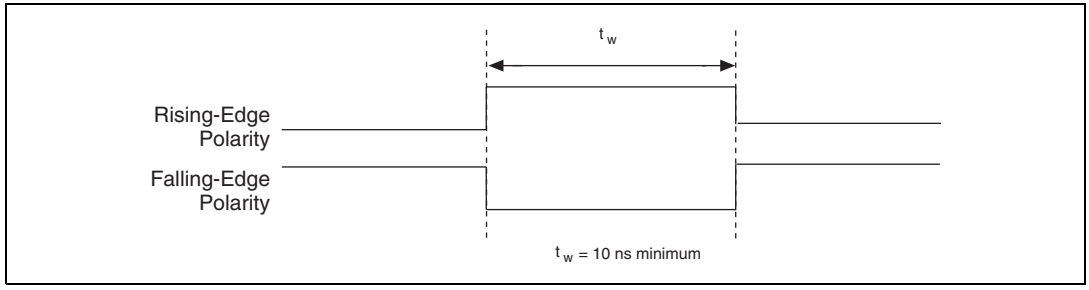


Figure 4-25. STARTSCAN Input Signal Timing

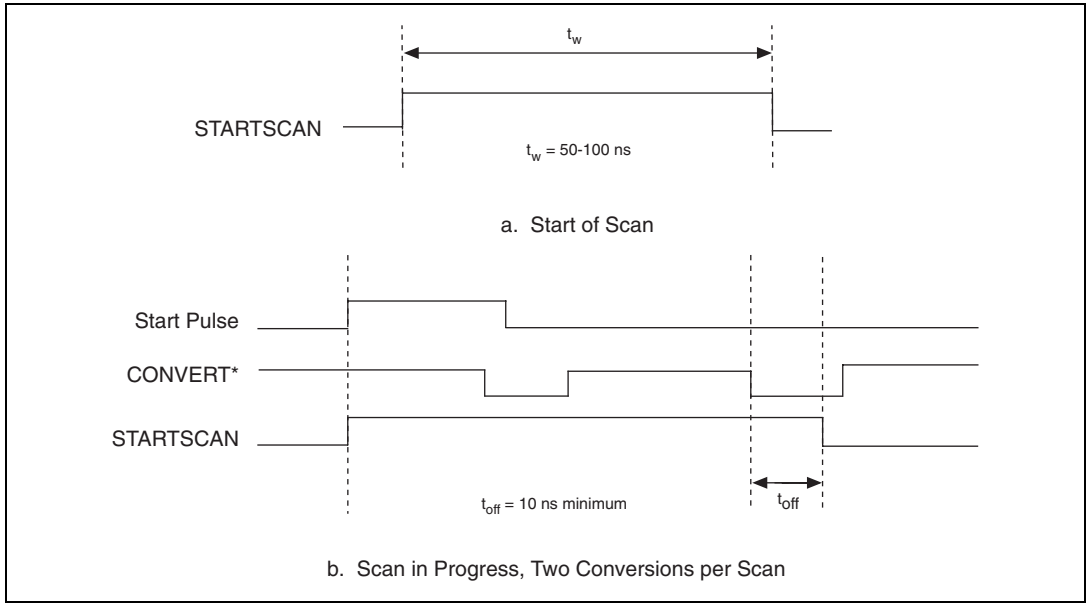


Figure 4-26. STARTSCAN Output Signal Timing

The CONVERT* pulses are masked off until the device generates the STARTSCAN signal. If you are using internally generated conversions, the first CONVERT* appears when the onboard sample interval counter reaches zero. If you select an external CONVERT*, the first external pulse after STARTSCAN generates a conversion. Separate the STARTSCAN pulses by at least one scan period.

A counter on your device internally generates the STARTSCAN signal unless you select some external source. This counter is started by the TRIG1 signal and is stopped either by software or by the sample counter.

Scans generated by either an internal or external STARTSCAN signal are inhibited unless they occur within a DAQ sequence. Scans occurring within a DAQ sequence can be gated by either the hardware (AIGATE) signal or software command register gate.

CONVERT* Signal

Any PFI pin can externally input the CONVERT* signal, which is available as an output on the PFI2/CONVERT* pin.

Refer to Figures 4-17 and 4-18 for the relationship of CONVERT* to the DAQ sequence.

As an input, the CONVERT* signal is configured in the edge-detection mode. You can select any PFI pin as the source for CONVERT* and configure the polarity selection for either rising or falling edge. The selected edge of the CONVERT* signal initiates an A/D conversion.

The ADC switches to hold mode within 60 ns of the selected edge. This hold-mode delay time is a function of temperature and does not vary from one conversion to the next. Separate the CONVERT* pulses by at least 5 µs (200 kHz sample rate).

As an output, the CONVERT* signal reflects the actual convert pulse that is connected to the ADC. This is true even if the conversions are externally generated by another PFI. The output is an active low pulse with a pulse width of 50 to 150 ns. This output is set to high impedance at startup.

Figures 4-27 and 4-28 show the input and output timing requirements for the CONVERT* signal.

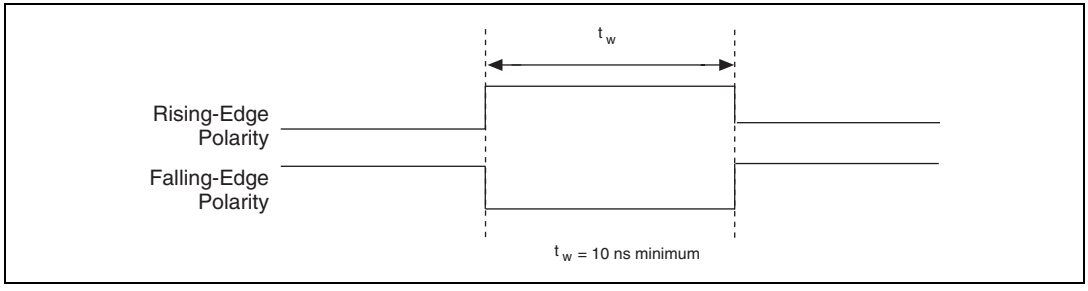


Figure 4-27. CONVERT* Input Signal Timing

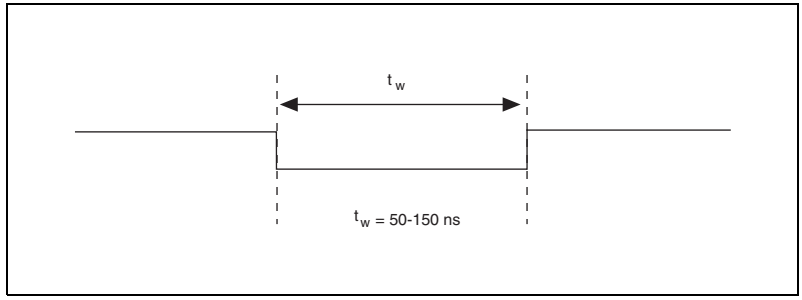


Figure 4-28. CONVERT* Output Signal Timing

The sample interval counter on the device normally generates the CONVERT* signal unless you select some external source. The counter is started by the STARTSCAN signal and continues to count down and reload itself until the scan is finished. It then reloads itself in preparation for the next STARTSCAN pulse.

A/D conversions generated by either an internal or external CONVERT* signal are inhibited unless they occur within a DAQ sequence. Scans occurring within a DAQ sequence can be gated by either the hardware (AIGATE) signal or software command register gate.

AIGATE Signal

Any PFI pin can externally input the AIGATE signal, which is not available as an output on the I/O connector. The AIGATE signal can mask off scans in a DAQ sequence. You can configure the PFI pin you select as the source for the AIGATE signal in either the level-detection or edge-detection mode. You can configure the polarity selection for the PFI pin for either active high or active low.

In the level-detection mode if AIGATE is active, the STARTSCAN signal is masked off and no scans can occur. In the edge-detection mode, the first active edge disables the STARTSCAN signal, and the second active edge enables STARTSCAN.

The AIGATE signal can neither stop a scan in progress nor continue a previously gated-off scan; in other words, once a scan has started, AIGATE does not gate off conversions until the beginning of the next scan and, conversely, if conversions are gated off, AIGATE does not gate them back on until the beginning of the next scan.

SISOURCE Signal

Any PFI pin can externally input the SISOURCE signal, which is not available as an output on the I/O connector. The onboard scan interval counter uses the SISOURCE signal as a clock to time the generation of the STARTSCAN signal. You must configure the PFI pin you select as the source for the SISOURCE signal in the level-detection mode. You can configure the polarity selection for the PFI pin for either active high or active low.

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

Either the 20 MHz or 100 kHz internal timebase generates the SISOURCE signal unless you select some external source. Figure 4-29 shows the timing requirements for the SISOURCE signal.

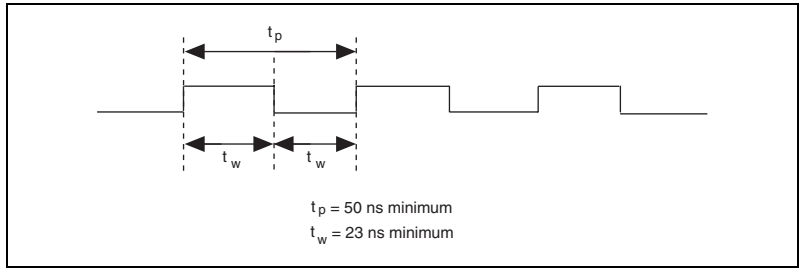


Figure 4-29. SISOURCE Signal Timing

Waveform Generation Timing Connections

The analog group defined for your device is controlled by WFTRIG, UPDATE*, and UISOURCE.

WFTRIG Signal

Any PFI pin can externally input the WFTRIG signal, which is available as an output on the PFI6/WFTRIG pin.

As an input, the WFTRIG signal is configured in the edge-detection mode. You can select any PFI pin as the source for WFTRIG and configure the polarity selection for either rising or falling edge. The selected edge of the WFTRIG signal starts the waveform generation for the DACs. The update interval (UI) counter is started if you select internally generated UPDATE*.

As an output, the WFTRIG signal reflects the trigger that initiates waveform generation. This is true even if the waveform generation is externally triggered by another PFI. The output is an active high pulse with a pulse width of 50 to 100 ns. This output is set to high impedance at startup.

Figures 4-30 and 4-31 show the input and output timing requirements for the WFTRIG signal.

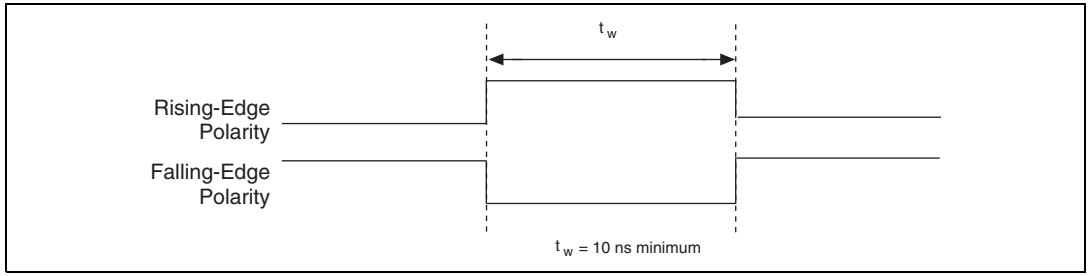


Figure 4-30. WFTRIG Input Signal Timing

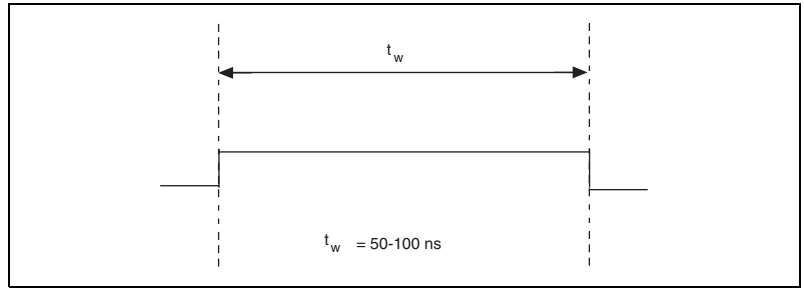


Figure 4-31. WFTRIG Output Signal Timing

UPDATE* Signal

Any PFI pin can externally input the UPDATE* signal, which is available as an output on the PFI5/UPDATE* pin.

As an input, the UPDATE* signal is configured in the edge-detection mode. You can select any PFI pin as the source for UPDATE* and configure the polarity selection for either rising or falling edge. The selected edge of the UPDATE* signal updates the outputs of the DACs. In order to use UPDATE*, you must set the DACs to posted-update mode.

As an output, the UPDATE* signal reflects the actual update pulse that is connected to the DACs. This is true even if the updates are externally generated by another PFI. The output is an active low pulse with a pulse width of 300 to 350 ns. This output is set to high impedance at startup.

Figures 4-32 and 4-33 show the input and output timing requirements for the UPDATE* signal.

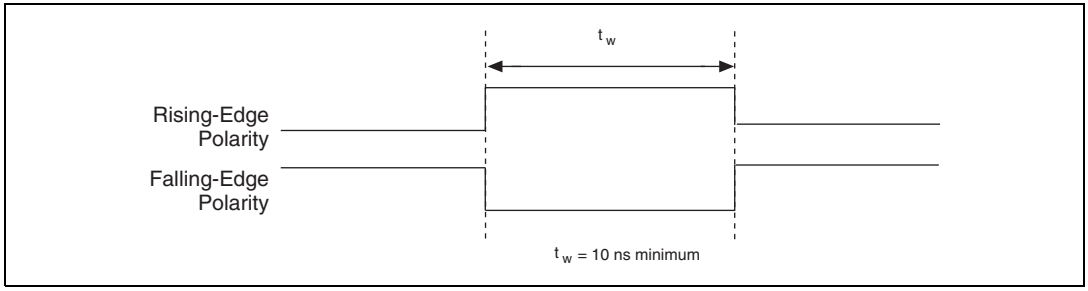


Figure 4-32. UPDATE* Input Signal Timing

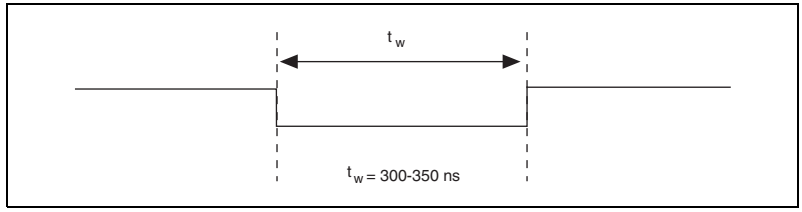


Figure 4-33. UPDATE* Output Signal Timing

The DACs are updated within 100 ns of the leading edge. Separate the UPDATE* pulses with enough time that new data can be written to the DAC latches.

The device UI counter normally generates the UPDATE* signal unless you select some external source. The UI counter is started by the WFTRIG signal and can be stopped by software or the internal Buffer Counter.

D/A conversions generated by either an internal or external UPDATE* signal do not occur when gated by the software command register gate.

UISOURCE Signal

Any PFI pin can externally input the UISOURCE signal, which is not available as an output on the I/O connector. The UI counter uses the UISOURCE signal as a clock to time the generation of the UPDATE*

signal. You must configure the PFI pin you select as the source for the UISOURCE signal in the level-detection mode. You can configure the polarity selection for the PFI pin for either active high or active low. Figure 4-34 shows the timing requirements for the UISOURCE signal.

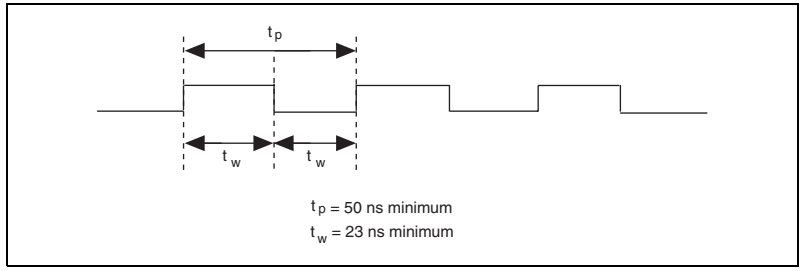


Figure 4-34. UISOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

Either the 20 MHz or 100 kHz internal timebase normally generates the UISOURCE signal unless you select some external source.

General-Purpose Timing Signal Connections

The general-purpose timing signals are GPCTR0_SOURCE, GPCTR0_GATE, GPCTR0_OUT, GPCTR0_UP_DOWN, GPCTR1_SOURCE, GPCTR1_GATE, GPCTR1_OUT, GPCTR1_UP_DOWN, and FREQ_OUT.

GPCTR0_SOURCE Signal

Any PFI pin can externally input the GPCTR0_SOURCE signal, which is available as an output on the PFI8/GPCTR0_SOURCE pin.

As an input, the GPCTR0_SOURCE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR0_SOURCE and configure the polarity selection for either rising or falling edge.

As an output, the GPCTR0_SOURCE signal reflects the actual clock connected to general-purpose counter 0. This is true even if another PFI is externally inputting the source clock. This output is set to high impedance at startup.

Figure 4-35 shows the timing requirements for the GPCTR0_SOURCE signal.

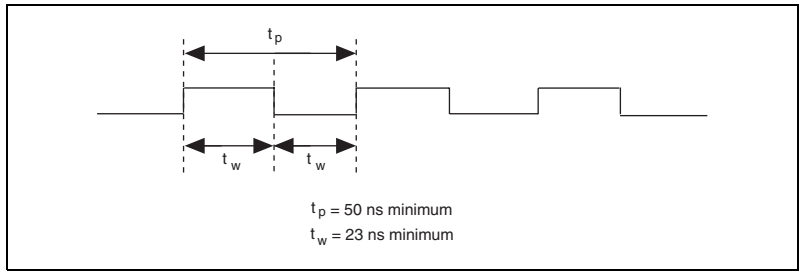


Figure 4-35. GPCTR0_SOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

The 20 MHz or 100 kHz timebase normally generates the GPCTR0_SOURCE signal unless you select some external source.

GPCTR0_GATE Signal

Any PFI pin can externally input the GPCTR0_GATE signal, which is available as an output on the PFI9/GPCTR0_GATE pin.

As an input, the GPCTR0_GATE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR0_GATE and configure the polarity selection for either rising or falling edge. You can use the gate signal in a variety of different applications to perform actions such as starting and stopping the counter, generating interrupts, saving the counter contents, and so on.

As an output, the GPCTR0_GATE signal reflects the actual gate signal connected to general-purpose counter 0. This is true even if the gate is externally generated by another PFI. This output is set to high impedance at startup. Figure 4-36 shows the timing requirements for the GPCTR0_GATE signal.

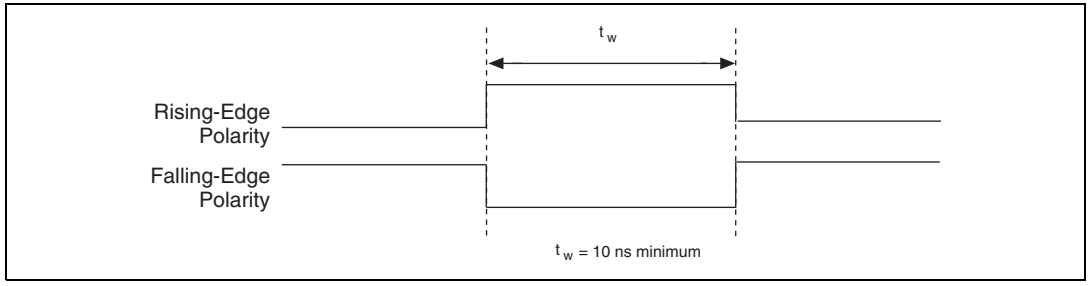


Figure 4-36. GPCTR0_GATE Signal Timing in Edge-Detection Mode

GPCTR0_OUT Signal

This signal is available only as an output on the GPCTR0_OUT pin. The GPCTR0_OUT signal reflects the terminal count (TC) of general-purpose counter 0. You have two software-selectable output options—pulse on TC and toggle output polarity on TC. The output polarity is software-selectable for both options. This output is set to high impedance at startup.
Figure 4-37 shows the timing of the GPCTR0_OUT signal.

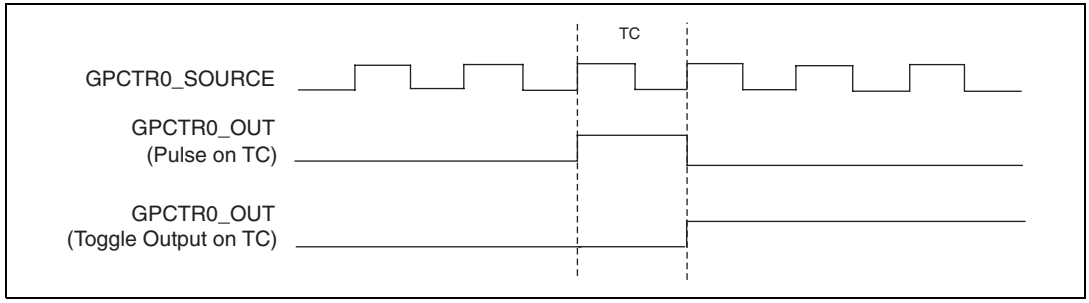


Figure 4-37. GPCTR0_OUT Signal Timing

GPCTR0_UP_DOWN Signal

This signal can be externally input on the DIO6 pin and is not available as an output on the I/O connector. The general-purpose counter 0 counts down when this pin is at a logic low and count up when it is at a logic high. You can disable this input so that software can control the up-down functionality and leave the DIO6 pin free for general use.

GPCTR1_SOURCE Signal

Any PFI pin can externally input the GPCTR1_SOURCE signal, which is available as an output on the PFI3/GPCTR1_SOURCE pin. As an input, the GPCTR1_SOURCE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR1_SOURCE and configure the polarity selection for either rising or falling edge.

As an output, the GPCTR1_SOURCE monitors the actual clock connected to general-purpose counter 1. This is true even if the source clock is externally generated by another PFI. This output is set to high impedance at startup.

Figure 4-38 shows the timing requirements for the GPCTR1_SOURCE signal.

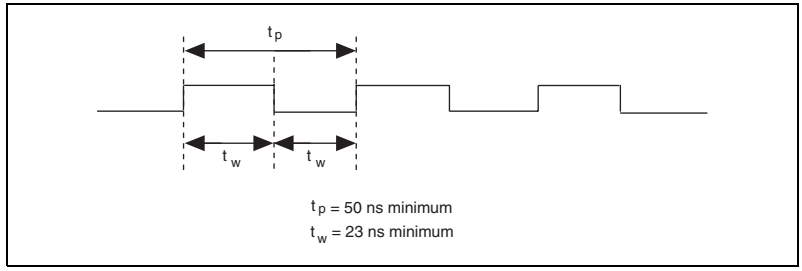


Figure 4-38. GPCTR1_SOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

The 20 MHz or 100 kHz timebase normally generates the GPCTR1_SOURCE unless you select some external source.

GPCTR1_GATE Signal

Any PFI pin can externally input the GPCTR1_GATE signal, which is available as an output on the PFI4/GPCTR1_GATE pin.

As an input, the GPCTR1_GATE signal is configured in edge-detection mode. You can select any PFI pin as the source for GPCTR1_GATE and configure the polarity selection for either rising or falling edge. You can use the gate signal in a variety of different applications to perform such actions as starting and stopping the counter, generating interrupts, saving the counter contents, and so on.

As an output, the GPCTR1_GATE signal monitors the actual gate signal connected to general-purpose counter 1. This is true even if the gate is externally generated by another PFI. This output is set to high impedance at startup.

Figure 4-39 shows the timing requirements for the GPCTR1_GATE signal.

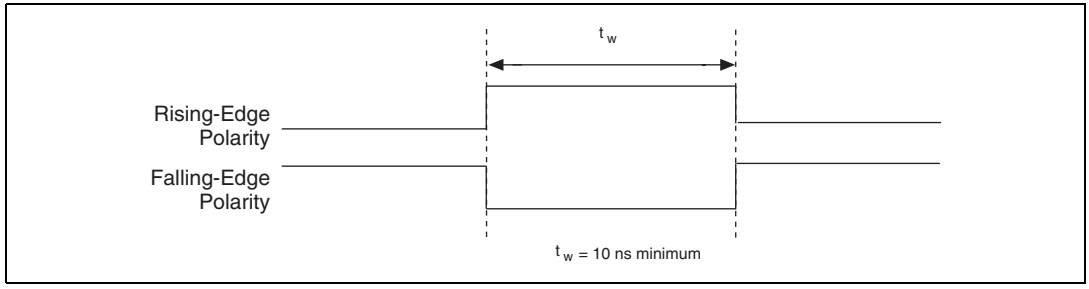


Figure 4-39. GPCTR1_GATE Signal Timing in Edge-Detection Mode

GPCTR1_OUT Signal

This signal is available only as an output on the GPCTR1_OUT pin. The GPCTR1_OUT signal monitors the TC device general-purpose counter 1. You have two software-selectable output options—pulse on TC and toggle output polarity on TC. The output polarity is software-selectable for both options. This output is set to high impedance at startup. Figure 4-40 shows the timing requirements for the GPCTR1_OUT signal.

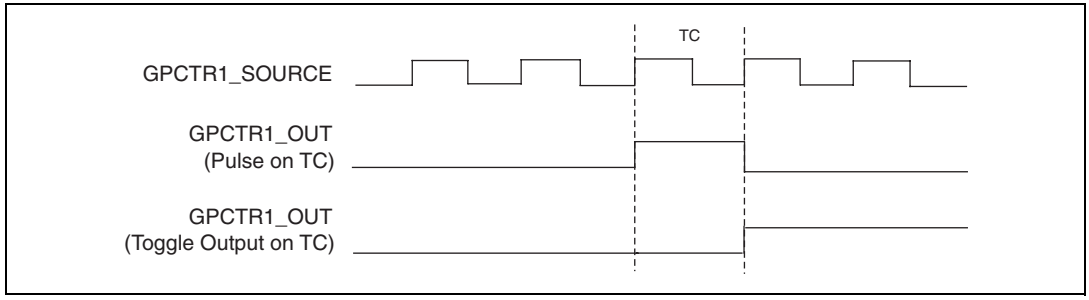


Figure 4-40. GPCTR1_OUT Signal Timing

GPCTR1_UP_DOWN Signal

This signal can be externally input on the DIO7 pin and is not available as an output on the I/O connector. General-purpose counter 1 counts down when this pin is at a logic low and counts up at a logic high. This input can be disabled so that software can control the up-down functionality and

leave the DIO7 pin free for general use. Figure 4-41 shows the timing requirements for the GATE and SOURCE input signals and the timing specifications for the OUT output signals of your device.

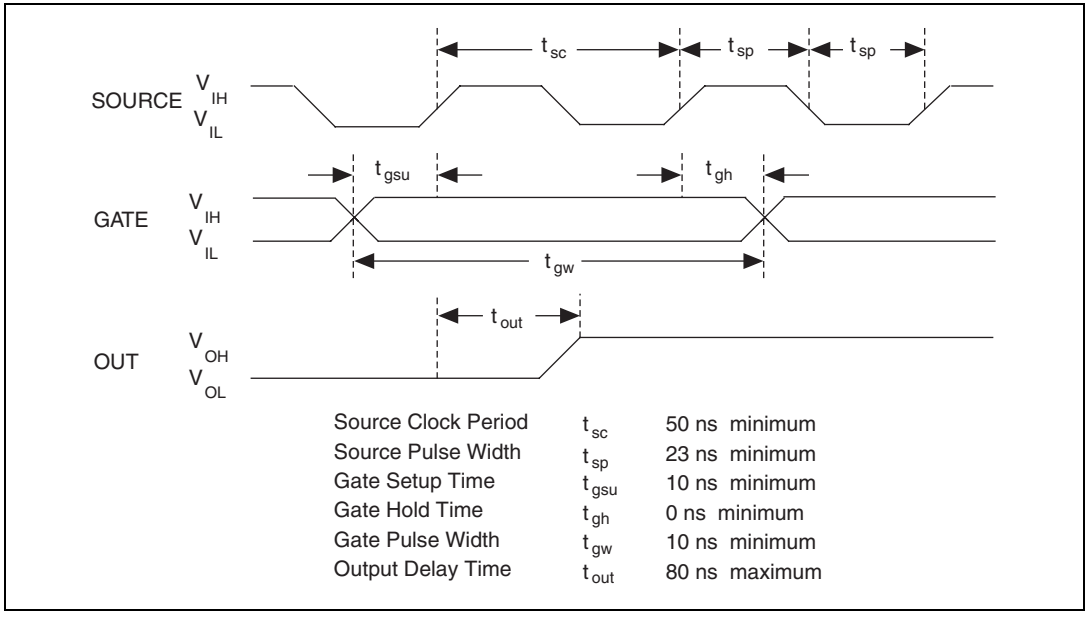


Figure 4-41. GPCTR Timing Summary

The GATE and OUT signal transitions shown in Figure 4-41 are referenced to the rising edge of the SOURCE signal. This timing diagram assumes that the counters are programmed to count rising edges. The same timing diagram, but with the source signal inverted and referenced to the falling edge of the source signal, applies when the counter is programmed to count falling edges.

The GATE input timing parameters are referenced to the signal at the SOURCE input or to one of the internally generated signals on your device. Figure 4-41 shows the GATE signal referenced to the rising edge of a source signal. The gate must be valid (either high or low) for at least 10 ns before the rising or falling edge of a source signal for the gate to take effect at that source edge, as shown by t_{gsu} and t_{gh} in Figure 4-41. The gate signal is not required to be held after the active edge of the source signal.

If you use an internal timebase clock, the gate signal cannot be synchronized with the clock. In this case, gates applied close to a source edge take effect either on that source edge or on the next one. This arrangement results in an uncertainty of one source clock period with respect to unsynchronized gating sources.

The OUT output timing parameters are referenced to the signal at the SOURCE input or to one of the internally generated clock signals on the devices. Figure 4-41 shows the OUT signal referenced to the rising edge of a source signal. Any OUT signal state changes occur within 80 ns after the rising or falling edge of the source signal.

FREQ_OUT Signal

This signal is available only as an output on the FREQ_OUT pin. The frequency generator of the device outputs the FREQ_OUT pin. The frequency generator is a 4-bit counter that can divide its input clock by the numbers 1 through 16. The input clock of the frequency generator is software-selectable from the internal 10 MHz and 100 kHz timebases. The output polarity is software-selectable. This output is set to high impedance at startup.

Field Wiring Considerations

Environmental noise can seriously affect the accuracy of measurements made with your device if you do not take proper care when running signal wires between signal sources and the device. The following recommendations apply mainly to analog input signal routing to the device, although they also apply to signal routing in general.

Minimize noise pickup and maximize measurement accuracy by taking the following precautions:

- Use DIFF analog input connections to reject common-mode noise.
- Use individually shielded, twisted-pair wires to connect analog input signals to the device. With this type of wire, the signals attached to the CH+ and CH– inputs are twisted together and then covered with a shield. You then connect this shield only at one point to the signal source ground. This kind of connection is required for signals traveling through areas with large magnetic fields or high electromagnetic interference.

5

Calibration

This chapter discusses the calibration procedures for your device. If you are using the NI-DAQ device driver, that software includes calibration functions for performing all of the steps in the calibration process.

Calibration refers to the process of minimizing measurement and output voltage errors by making small circuit adjustments. For these devices, these adjustments take the form of writing values to onboard calibration DACs (CalDACs).

Some form of device calibration is required for all but the most forgiving applications. If you do not calibrate your device, your signals and measurements could have very large offset, gain, and linearity errors.

Three levels of calibration are available to you and described in this chapter. The first level is the fastest, easiest, and least accurate, whereas the last level is the slowest, most difficult, and most accurate.

Loading Calibration Constants

Your device is factory calibrated before shipment at approximately 25 °C to the levels indicated in Appendix A, *Specifications*. The associated calibration constants—the values that were written to the CalDACs to achieve calibration in the factory—are stored in the onboard nonvolatile memory (EEPROM). Because the CalDACs have no memory capability, they do not retain calibration information when the device is unpowered. Loading calibration constants refers to the process of loading the CalDACs with the values stored in the EEPROM. NI-DAQ software determines when this is necessary and does it automatically. If you are not using NI-DAQ, you must load these values yourself.

In the EEPROM there is a user-modifiable calibration area in addition to the permanent factory calibration area. This means that you can load the CalDACs with values either from the original factory calibration or from a calibration that you subsequently performed.

This method of calibration is not very accurate because it does not take into account the fact that the device measurement and output voltage errors can vary with time and temperature. It is better to self-calibrate the device when it is installed in the environment in which it will be used.

Self-Calibration

Your device can measure and correct for almost all of its calibration-related errors without any external signal connections. Your National Instruments software provides a self-calibration method. This self-calibration process, which generally takes less than a minute, is the preferred method of assuring accuracy in your application. Initiate self-calibration to minimize the effects of any offset, gain, and linearity drifts, particularly those due to warmup.

Immediately after self-calibration, the only significant residual calibration error could be gain error due to time or temperature drift of the onboard voltage reference. This error is addressed by external calibration, which is discussed in the following section. If you are interested primarily in relative measurements, you can ignore a small amount of gain error, and self-calibration should be sufficient.

External Calibration

Your device has an onboard calibration reference to ensure the accuracy of self-calibration. Its specifications are listed in Appendix A, *Specifications*. The reference voltage is measured at the factory and stored in the EEPROM for subsequent self-calibrations. This voltage is stable enough for most applications, but if you are using your device at an extreme temperature or if the onboard reference has not been measured for a year or more, you may wish to externally calibrate your device.

An external calibration refers to calibrating your device with a known external reference rather than relying on the onboard reference. Redetermining the value of the onboard reference is part of this process and you can save the results in the EEPROM, so you should not have to perform an external calibration very often. You can externally calibrate your device by calling the NI-DAQ calibration function.

To externally calibrate your device, be sure to use a very accurate external reference. Use a reference that is several times more accurate than the device itself.

Other Considerations

The CalDACs adjust the gain error of each analog output channel by adjusting the value of the reference voltage supplied to that channel. This calibration mechanism is designed to work only with the internal 10 V reference. Thus, in general, it is not possible to calibrate the analog output gain error when using an external reference. In this case, it is advisable to account for the nominal gain error of the analog output channel either in software or with external hardware. See Appendix A, *Specifications*, for analog output gain error information.

A

Specifications

This appendix individually lists the specifications of each bus type and are typical at 25 °C.

PCI and PXI Buses

Analog Input

Input Characteristics

Number of channels ..... 16 single-ended or 8 differential (software-selectable per channel)

Type of ADC..... Successive approximation

Resolution ..... 12 bits, 1 in 4,096

Sampling rate ..... 200 kS/s guaranteed

Input signal ranges ..... Bipolar only

Board Gain (Software-Selectable)	Range
0.5	±10 V
1	±5 V
10	±500 mV
100	±50 mV

Input coupling ..... DC

Max working voltage (signal + common mode) ..... Each input should remain within ±11 V of ground

Overvoltage protection

Signal	Powered On	Powered Off
ACH<0..15>	±42	±35
AISENSE	±40	±25

FIFO buffer size.....512 S

Data transfers.....DMA, interrupts, programmed I/O

DMA modes .....Scatter-gather (single transfer, demand transfer)

Configuration memory size .....512 words

Accuracy Information

Nominal Range (V)		Absolute Accuracy							Relative Accuracy	
		% of Reading		Offset (mV)	Noise + Quantization (mV)		Temp Drift (%/ °C)	Absolute Accuracy at Full Scale (mV)	Resolution (mV)	
Positive FS	Negative FS	24 Hours	1 Year		Single Pt.	Averaged			Single Pt.	Averaged
10	–10	0.0872	0.0914	6.38	3.91	0.975	0.0010	16.504	5.89	1.28
5	–5	0.0272	0.0314	3.20	1.95	0.488	0.0005	5.263	2.95	0.642
0.5	–0.5	0.0872	0.0914	0.340	0.195	0.049	0.0010	0.846	0.295	0.064
0.05	–0.05	0.0872	0.0914	0.054	0.063	0.006	0.0010	0.106	0.073	0.008

Note: Accuracies are valid for measurements following an internal E Series calibration. Averaged numbers assume dithering and averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. One-year calibration interval recommended. The Absolute Accuracy at Full Scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 pt averaging of data.

Transfer Characteristics

Relative accuracy ..... ±0.5 LSB typ dithered,
±1.5 LSB max undithered

DNL ..... ±0.5 LSB typ, ±1.0 LSB max

No missing codes ..... 12 bits, guaranteed

Offset error

- Pregain error after calibration ..... ±12 μV max
- Pregain error before calibration ..... ±28 mV max
- Postgain error after calibration ..... ±0.5 mV max
- Postgain error before calibration..... ±100 mV max

Gain error (relative to calibration reference)

- After calibration (gain = 1) ..... ±0.02% of reading max
- Before calibration ..... ±2.75% of reading max
- Gain ≠ 1 with gain error
  adjusted to 0 at gain = 1 ..... ±0.05% of reading max

Amplifier Characteristics

Input impedance

- Normal powered on ..... 100 GΩ in parallel with 100 pF
- Powered off..... 4 kΩ min
- Overload..... 4 kΩ min

Input bias current ..... ±200 pA

Input offset current..... ±100 pA

CMRR (DC to 60 Hz)

- Gain 0.5, 1.0..... 85 dB
- Gain 10, 100..... 90 dB

Dynamic Characteristics

Bandwidth

Signal	Bandwidth
Small (–3 dB)	500 kHz
Large (1% THD)	225 kHz

Settling time for full-scale step.....5 µs max to ±1.0 LSB accuracy

System noise (LSB_{rms}, not including quantization)

Gain	Dither Off	Dither On
0.5 to 10	0.1	0.6
100	0.7	0.8

Crosstalk .....–60 dB, DC to 100 kHz

Stability

Recommended warm-up time.....15 min.

Offset temperature coefficient

Pregain.....±15 µV/°C

Postgain .....±240 µV/°C

Gain temperature coefficient .....±20 ppm/°C

Analog Output

- 6024E and 6025E only

Output Characteristics

Number of channels.....2 voltage

Resolution.....12 bits, 1 in 4,096

Max update rate

DMA.....10 kHz, system dependent

Interrupts.....1 kHz, system dependent

Type of DAC .....Double buffered, multiplying

FIFO buffer size ..... None

Data transfers ..... DMA, interrupts, programmed I/O

DMA modes ..... Scatter-gather (Single transfer, demand transfer)

Accuracy Information

Nominal Range (V)		Absolute Accuracy					Absolute Accuracy at Full Scale (mV)
		% of Reading			Offset (mV)	Temp Drift (%/ °C)	
Positive FS	Negative FS	24 Hours	90 Days	1 Year			
10	–10	0.0177	0.0197	0.0219	5.93	0.0005	8.127
Note: Temp Drift applies only if ambient is greater than ±10 °C of previous external calibration.							

Transfer Characteristics

Relative accuracy (INL)

After calibration ..... ±0.3 LSB typ, ±0.5 LSB max

Before calibration ..... ±4 LSB max

DNL

After calibration ..... ±0.3 LSB typ, ± 1.0 LSB max

Before calibration ..... ±3 LSB max

Monotonicity ..... 12 bits, guaranteed after calibration

Offset error

After calibration ..... ±1.0 mV max

Before calibration ..... ±200 mV max

Gain error (relative to internal reference)

After calibration ..... ±0.01% of output max

Before calibration ..... ±0.75% of output max

Voltage Output

Range .....± 10 V

Output coupling .....DC

Output impedance .....0.1 Ω max

Current drive .....±5 mA max

Protection .....Short-circuit to ground

Power-on state (steady state) .....±200 mV

Initial power-up glitch

- Magnitude .....±1.1 V
- Duration ..... 2.0 ms

Power reset glitch

- Magnitude .....±2.2 V
- Duration ..... 4.2 µs

Dynamic Characteristics

Settling time for full-scale step .....10 µs to ±0.5 LSB accuracy

Slew rate .....10 V/µs

Noise .....200 μV_{rms}, DC to 1 MHz

Midscale transition glitch

- Magnitude .....±45 mV
- Duration ..... 2.0 µs

Stability

Offset temperature coefficient .....±50 µV/°C

Gain temperature coefficient .....±25 ppm/°C

Digital I/O

Number of channels

6025E ..... 32 input/output

6023E and 6024E ..... 8 input/output

Compatibility ..... TTL/CMOS

DIO<0..7>

Digital logic levels

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2 V	5 V
Input low current (V_{in} = 0 V)	—	–320 µA
Input high current (V_{in} = 5 V)	—	10 µA
Output low voltage (I_{OL} = 24 mA)	—	0.4 V
Output high voltage (I_{OH} = 13 mA)	4.35 V	—

Power-on state ..... Input (High-Z),
50 kΩ pull up to +5 VDC

Data transfers ..... Programmed I/O

PA<0..7>,PB<0..7>,PC<0..7>

♦ 6025E only

Digital logic levels

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2.2 V	5 V
Input low current (V_{in} = 0 V, 100 kΩ pull up)	—	–75 µA
Input high current (V_{in} = 5 V, 100 kΩ pull up)	—	10 µA
Output low voltage (I_{OL} = 2.5 mA)	—	0.4 V
Output high voltage (I_{OH} = 2.5 mA)	3.7 V	—

Handshaking 2-wire

Power-on state

PA<0..7> .....Input (High-Z), 100 kΩ pull-up to +5 VDC

PB<0..7>.....Input (High-Z), 100 kΩ pull-up to +5 VDC

PC<0..7>.....Input (High-Z), 100 kΩ pull-up to +5 VDC

Data transfers.....Interrupts, programmed I/O

Timing I/O

Number of channels.....2 up/down counter/timers, 1 frequency scaler

Resolution

Counter/timers .....24 bits

Frequency scalers .....4 bits

Compatibility .....TTL/CMOS

Base clocks available

Counter/timers .....20 MHz, 100 kHz

Frequency scalers .....10 MHz, 100 kHz

Base clock accuracy.....±0.01%

Max source frequency.....20 MHz

Min source pulse duration .....10 ns in edge-detect mode

Min gate pulse duration .....10 ns in edge-detect mode

Data transfers.....DMA, interrupts, programmed I/O

DMA modes .....Scatter-gather (single transfer, demand transfer)

Triggers

Digital Trigger

Compatibility ..... TTL

Response ..... Rising or falling edge

Pulse width ..... 10 ns min

RTSI

Trigger lines 7

Calibration

Recommended warm-up time ..... 15 min

Interval ..... 1 year

External calibration reference ..... > 6 and < 10 V

Onboard calibration reference

- Level ..... 5.000 V (±3.5 mV) (actual value stored in EEPROM)
- Temperature coefficient ..... ±5 ppm/°C max
- Long-term stability ..... ±15 ppm/$\sqrt{1,000\ \text{h}}$

Power Requirement

+5 VDC (±5%) ..... 0.7 A

Note Excludes power consumed through V_{cc} available at the I/O connector.

Power available at I/O connector ..... +4.65 to +5.25 VDC at 1 A

Physical

Dimensions (not including connectors)

- PCI devices ..... 17.5 by 10.6 cm (6.9 by 4.2 in.)
- PXI devices ..... 16.0 by 10.0 cm (6.3 by 3.9 in.)

I/O connector

6023E/6024E .....68-pin male SCSI-II type

6025E.....100-pin female 0.05D type

Operating Environment

Ambient temperature .....0 to 55 °C

Relative humidity .....10 to 90% noncondensing

- PXI-6025E only

Functional shock.....MIL-T-28800 E Class 3 (per Section 4.5.5.4.1) Half-sine shock pulse, 11 ms duration, 30 g peak, 30 shocks per face

Operational random vibration.....5 to 500 Hz, 0.31 g_{rms}, 3 axes

Storage Environment

Ambient temperature .....–20 to 70 °C

Relative humidity .....5% to 95% noncondensing

- PXI-6025E only

Non-operational random vibration .....5 to 500 Hz, 2.5 g_{rms}, 3 axes

Note Random vibration profiles for the PXI-6025E were developed in accordance with MIL-T-28800E and MIL-STD-810E Method 514. Test levels exceed those recommended in MIL-STD-810E for Category 1, Basic Transportation.

PCMCIA Bus

Analog Input

Input Characteristics

Number of channels ..... 16 single-ended or 8 differential (software-selectable per channel)

Type of ADC..... Successive approximation

Resolution ..... 12 bits, 1 in 4,096

Sampling rate ..... 200 kS/s guaranteed

Input signal ranges ..... Bipolar only

Board Gain (Software-Selectable)	Range
0.5	±10 V
1	±5 V
10	±500 mV
100	±50 mV

Input coupling ..... DC

Max working voltage (signal + common mode) ..... Each input should remain within ±11 V of ground

Overvoltage protection

Signal	Powered On	Powered Off
ACH<0..15>	±42	±35
AISENSE	±40	±25

FIFO buffer size ..... 2048 S

Data transfers ..... Interrupts, programmed I/O

Configuration memory size..... 512 words

Accuracy Information

Nominal Range (V)		Absolute Accuracy							Relative Accuracy	
		% of Reading			Noise + Quantization (mV)				Resolution (mV)	
Positive FS	Negative FS	24 Hours	1 Year	Offset (mV)	Single Pt.	Averaged	Temp Drift (%/°C)	Absolute Accuracy at Full Scale (mV)	Single Pt.	Averaged
10	–10	0.0872	0.0914	8.83	3.91	1.042	0.0010	19.012	5.89	1.37
5	–5	0.0272	0.0314	4.42	1.95	0.521	0.0005	6.517	2.95	0.686
0.5	–0.5	0.0872	0.0914	0.462	0.452	0.052	0.0010	0.972	0.516	0.069
0.05	–0.05	0.0872	0.0914	0.066	0.063	0.007	0.0010	0.119	0.073	0.009

Note: Accuracies are valid for measurements following an internal E Series calibration. Averaged numbers assume dithering and averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory calibration temperature.

Transfer Characteristics

Relative accuracy.....±0.5 LSB typ dithered,
±1.5 LSB max undithered

DNL.....±0.75 LSB typ,
–0.9 to +1.5 LSB max

No missing codes.....12 bits, guaranteed

Offset error

- Pregain error after calibration.....±12 µV max
- Pregain error before calibration.....±28 mV max
- Postgain error after calibration.....±0.5 mV max
- Postgain error before calibration.....±100 mV max

Gain error (relative to calibration reference)

- After calibration (gain = 1).....±0.02% of reading max
- Before calibration.....±2.75% of reading max
- Gain ≠ 1 with gain error adjusted to 0 at gain = 1.....±0.05% of reading max

Amplifier Characteristics

Input impedance

Normal powered on ..... 100 GΩ in parallel with 100 pF

Powered off..... 4 kΩ min

Overload..... 4 kΩ min

Input bias current ..... ±200 pA

Input offset current..... ±100 pA

CMRR (DC to 60 Hz)

Gain 0.5, 1.0..... 85 dB

Gain 10, 100..... 90 dB

Dynamic Characteristics

Bandwidth

Signal	Bandwidth
Small (–3 dB)	500 kHz
Large (1% THD)	225 kHz

Settling time for full-scale step ..... 5 µs max to ±1.0 LSB accuracy

System noise (LSB_{rms}, not including quantization)

Gain	Dither Off	Dither On
0.5 to 1	0.10	0.65
10	0.45	0.65
100	0.70	0.90

Crosstalk..... –60 dB, DC to 100 kHz

Stability

Recommended warm-up time ..... 30 min

Offset temperature coefficient

Pregain ..... ±15 µV/°C

Postgain..... ±240 µV/°C

Gain temperature coefficient .....±20 ppm/°C

Analog Output

Output Characteristics

Number of channels.....2 voltage

Resolution.....12 bits, 1 in 4,096

Max update rate

Interrupts.....1 kHz, system dependent

Type of DAC .....Double buffered, multiplying

FIFO buffer size.....None

Data transfers.....Interrupts, programmed I/O

Accuracy Information

Nominal Range (V)		Absolute Accuracy					Absolute Accuracy at Full Scale (mV)
		% of Reading					
Positive FS	Negative FS	24 Hours	90 Days	1 Year	Offset (mV)	Temp Drift (%/ °C)	
10	–10	0.0177	0.0197	0.0219	5.93	0.0005	8.127
Note: Temp Drift applies only if ambient is greater than ±10 °C of previous external calibration.							

Transfer Characteristics

Relative accuracy (INL)

After calibration.....±0.5 LSB typ, ±1.0 LSB max

Before calibration .....±4 LSB max

DNL

After calibration.....±0.5 LSB typ, ± 1.0 LSB max

Before calibration .....±3 LSB max

Monotonicity .....12 bits, guaranteed after calibration

Offset error

After calibration ..... ±1.0 mV max

Before calibration ..... ±200 mV max

Gain error (relative to internal reference)

After calibration ..... ±0.01% of output max

Before calibration ..... ±0.75% of output max

Voltage Output

Range ..... ± 10 V

Output coupling..... DC

Output impedance ..... 0.1 Ω max

Current drive ..... ±5 mA max

Protection ..... Short-circuit to ground

Power-on state (steady state)..... ±200 mV

Initial power-up glitch

Magnitude ..... ±1.5 V

Duration ..... 1.0 s

Power reset glitch

Magnitude ..... ±1.5 V

Duration ..... 1.0 s

Dynamic Characteristics

Settling time for full-scale step ..... 10 µs to ±0.5 LSB accuracy

Slew rate..... 10 V/µs

Noise ..... 200 µVrms, DC to 1 MHz

Midscale transition glitch

Magnitude ..... ±20 mV

Duration ..... 2.5 µs

Stability

Offset temperature coefficient .....±50 µV/°C

Gain temperature coefficient .....±25 ppm/°C

Digital I/O

Number of channels.....8 input/output

Compatibility.....TTL/CMOS

DIO<0..7>

Digital logic levels

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2 V	5 V
Input low current (V_{in} = 0 V)	—	–320 µA
Input high current (V_{in} = 5 V)	—	10 µA
Output low voltage (I_{OL} = 24 mA)	—	0.4 V
Output high voltage (I_{OH} = 13 mA)	4.35 V	—

Power-on state.....Input (High-Z),
50 kΩ pull up to +5 VDC

Data transfers.....Programmed I/O

Timing I/O

Number of channels.....2 up/down counter/timers,
1 frequency scaler

Resolution

Counter/timers .....24 bits

Frequency scalers .....4 bits

Compatibility.....TTL/CMOS

Base clocks available
- Counter/timers ..... 20 MHz, 100 kHz
- Frequency scalers..... 10 MHz, 100 kHz

Base clock accuracy ..... ±0.01%

Max source frequency ..... 20 MHz

Min source pulse duration..... 10 ns in edge-detect mode

Min gate pulse duration..... 10 ns in edge-detect mode

Data transfers ..... Interrupts, programmed I/O

Triggers

Digital Trigger

Compatibility ..... TTL

Response ..... Rising or falling edge

Pulse width..... 10 ns min

Calibration

Recommended warm-up time ..... 30 min

Interval ..... 1 year

External calibration reference ..... > 6 and < 10 V

Onboard calibration reference
- Level ..... 5.000 V (±3.5 mV) (actual value stored in EEPROM)
- Temperature coefficient..... ±5 ppm/°C max
- Long-term stability ..... ±15 ppm/$\sqrt{1,000\ \text{h}}$

Power Requirement

+5 VDC (±5%)..... 270 mA

Note Excludes power consumed through V_{cc} available at the I/O connector.

Power available at I/O connector ..... +4.65 to +5.25 VDC at 0.75 A

Physical

PC card type.....Type II

I/O connector .....68-position VHDCI female connector

Environment

Operating temperature .....0 to 40 °C with a maximum internal device temperature of 70 °C as measured by onboard temperature sensor.

Storage temperature.....–20 to 70 °C

Relative humidity .....10 to 95% non-condensing

B

Custom Cabling and Optional Connectors

This appendix describes the various cabling and connector options for the DAQCard-6024E, PCI-6023E, PCI-6024E, PCI-6025E, and PXI-6025E devices.

Custom Cabling

National Instruments offers cables and accessories for you to prototype your application or to use if you frequently change device interconnections.

If you want to develop your own cable, however, use the following guidelines:

- For the analog input signals, shielded twisted-pair wires for each analog input pair yield the best results, assuming that you use differential inputs. Tie the shield for each signal pair to the ground reference at the source.
- Route the analog lines separately from the digital lines.
- When using a cable shield, use separate shields for the analog and digital parts of the cable. Failure to do so results in noise coupling into the analog signals from transient digital signals.

The following list gives recommended connectors that mate to the I/O connector on your device.

♦ PCI-6023E and PCI-6024E

Honda 68-position, solder cup, female connector

Honda backshell

♦ DAQCard-6024E

Honda 68-Position, VHDCI

- 6025E

  AMP 100-position IDC male connector

  AMP backshell, 0.50 max O.D. cable

  AMP backshell, 0.55 max O.D. cable

  Mating connectors and a backshell kit for making custom 68-pin cables are available from National Instruments.

Optional Connectors

The following table shows the optional connector and cable assembly combinations you can use for each device.

Device	Connector	Cable Assembly
PCI-6023E/6024E	68-Pin E Series	SH6868, R6868
	50-Pin E Series	SH6850, R6850
DAQCard-6024E	68-Pin E Series	SHC68-68-EP, RC68-68
	50-Pin E Series	68M-50F adapter plus SHC68-68-EP or RC68-68 cable
6025E	MIO-16 68-Pin, 68-Pin Extended Digital Input	SH1006868
	50-Pin E Series, 50-Pin Extended Digital Input	RI005050

Figure B-1 shows the pin assignments for the 68-Pin E Series connector.

ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
DAC0OUT[1]	22	56	AIGND
DAC1OUT[1]	21	55	AOGND
RESERVED	20	54	AOGND
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5 V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5 V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5/UPDATE*	6	40	GPCTR1_OUT
PFI6/WFTRIG	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

[1] Not available on the 6023E

Figure B-1. 68-Pin E Series Connector Pin Assignments

Figure B-2 shows the pin assignments for the 68-pin extended digital input connector.

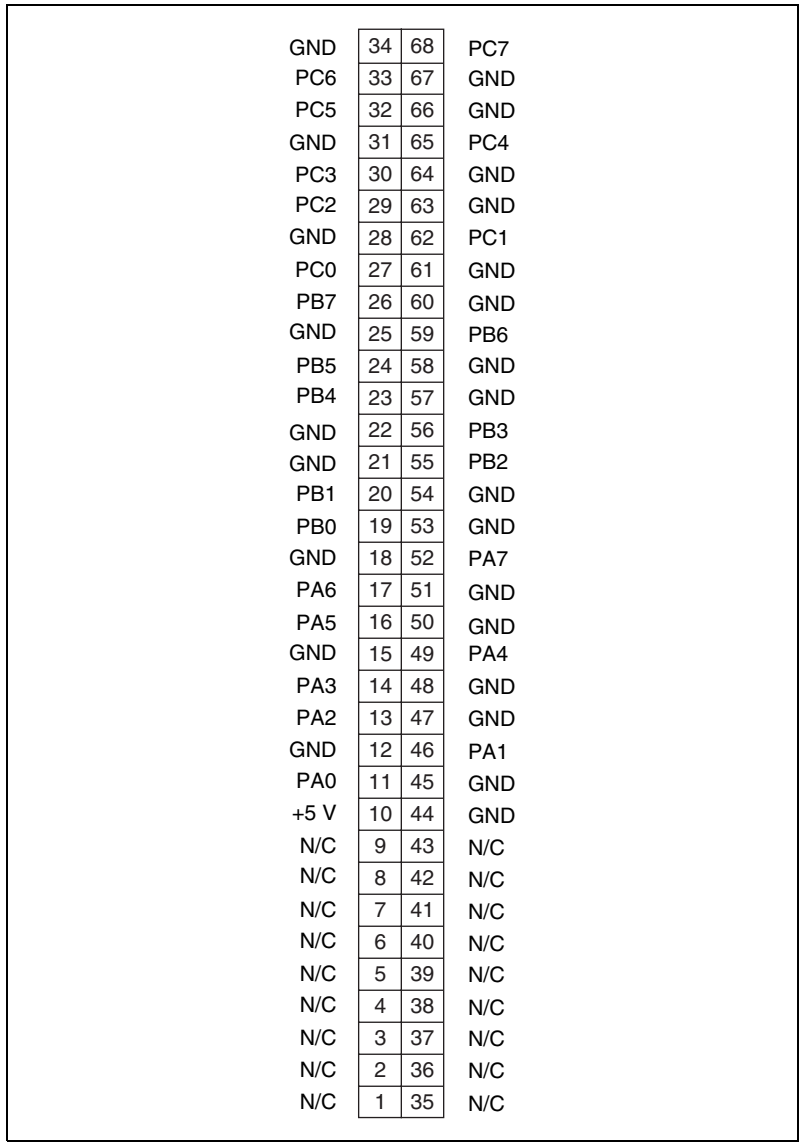

GND 34 68 PC7
PC6 33 67 GND
PC5 32 66 GND
GND 31 65 PC4
PC3 30 64 GND
PC2 29 63 GND
GND 28 62 PC1
PC0 27 61 GND
PB7 26 60 GND
GND 25 59 PB6
PB5 24 58 GND
PB4 23 57 GND
GND 22 56 PB3
GND 21 55 PB2
PB1 20 54 GND
PB0 19 53 GND
GND 18 52 PA7
PA6 17 51 GND
PA5 16 50 GND
GND 15 49 PA4
PA3 14 48 GND
PA2 13 47 GND
GND 12 46 PA1
PA0 11 45 GND
+5 V 10 44 GND
N/C 9 43 N/C
N/C 8 42 N/C
N/C 7 41 N/C
N/C 6 40 N/C
N/C 5 39 N/C
N/C 4 38 N/C
N/C 3 37 N/C
N/C 2 36 N/C
N/C 1 35 N/C

Figure B-2. 68-Pin Extended Digital Input Connector Pin Assignments

Figure B-3 shows the pin assignments for the 50-pin E Series connector.

AIGND	1	2	AIGND
ACH0	3	4	ACH8
ACH1	5	6	ACH9
ACH2	7	8	ACH10
ACH3	9	10	ACH11
ACH4	11	12	ACH12
ACH5	13	14	ACH13
ACH6	15	16	ACH14
ACH7	17	18	ACH15
AISENSE	19	20	DAC0OUT[1]
DAC1OUT[1]	21	22	RESERVED
AOGND	23	24	DGND
DIO0	25	26	DIO4
DIO1	27	28	DIO5
DIO2	29	30	DIO6
DIO3	31	32	DIO7
DGND	33	34	+5 V
+5 V	35	36	SCANCLK
EXTSTROBE*	37	38	PFI0/TRIG1
PFI1/TRIG2	39	40	PFI2/CONVERT*
PFI3/GPCTR1_SOURCE	41	42	PFI4/GPCTR1_GATE
GPCTR1_OUT	43	44	PFI5/UPDATE*
PFI6/WFTRIG	45	46	PFI7/STARTSCAN
PFI8/GPCTR0_SOURCE	47	48	PFI9/GPCTR0_GATE
GPCTR0_OUT	49	50	FREQ_OUT

[1] Not available on the 6023E

Figure B-3. 50-Pin E Series Connector Pin Assignments

Figure B-4 shows the pin assignments for the 50-pin extended digital input connector.

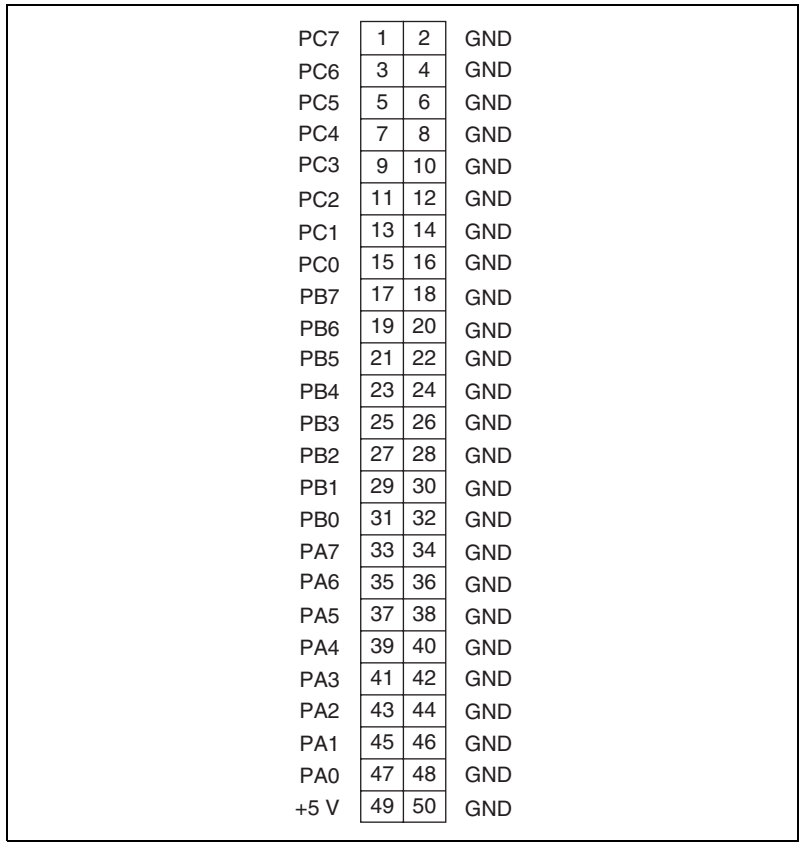

PC7 1 2 GND
PC6 3 4 GND
PC5 5 6 GND
PC4 7 8 GND
PC3 9 10 GND
PC2 11 12 GND
PC1 13 14 GND
PC0 15 16 GND
PB7 17 18 GND
PB6 19 20 GND
PB5 21 22 GND
PB4 23 24 GND
PB3 25 26 GND
PB2 27 28 GND
PB1 29 30 GND
PB0 31 32 GND
PA7 33 34 GND
PA6 35 36 GND
PA5 37 38 GND
PA4 39 40 GND
PA3 41 42 GND
PA2 43 44 GND
PA1 45 46 GND
PA0 47 48 GND
+5 V 49 50 GND

Figure B-4. 50-Pin Extended Digital Input Connector Pin Assignments

C

Common Questions

This appendix contains a list of commonly asked questions and their answers relating to usage and special features of your device.

General Information

What is the DAQ-STC?

The DAQ-STC is the system timing control application-specific integrated circuit (ASIC) designed by National Instruments and is the backbone of the E Series devices. The DAQ-STC contains seven 24-bit counters and three 16-bit counters. The counters are divided into the following three groups:

- Analog input—two 24-bit, two 16-bit counters
- Analog output—three 24-bit, one 16-bit counters
- General-purpose counter/timer functions—two 24-bit counters

You can configure the groups independently with timing resolutions of 50 ns or 10 µs. With the DAQ-STC, you can interconnect a wide variety of internal timing signals to other internal blocks. The interconnection scheme is quite flexible and completely software configurable. New capabilities such as buffered pulse generation, equivalent time sampling, and seamless changing of the sampling rate are possible.

What does sampling rate mean to me?

It means that this is the fastest you can acquire data on your device and still achieve accurate results. For example, these devices have a sampling rate of 200 kS/s. This sampling rate is aggregate—one channel at 200 kS/s or two channels at 100 kS/s per channel illustrates the relationship.

What type of 5 V protection do the devices have?

The PCI and PXI devices have 5 V lines equipped with a self-resetting 1 A fuse. The PCMCIA cards have 5 V lines equipped with a self-resetting 0.75 A fuse.

Installation and Configuration

How do I set the base address for my device?

The base address of your device is assigned automatically through the PCI/PXI bus protocol. This assignment is completely transparent to you.

What jumpers should I be aware of when configuring my E Series device?

The E Series devices are jumperless and switchless.

Which National Instruments document should I read first to get started using DAQ software?

Your NI-DAQ or application software release notes documentation is always the best starting place.

What version of NI-DAQ must I have to use my 6023E/6024E/6025E?

You must have *NI-DAQ for PC Compatibles* version 6.5 or higher to use a PCI a PXI device. To use the DAQCard-6024E you must have NI-DAQ for PC compatibles version 6.9 or higher.

Analog Input and Output

I'm using my device in differential analog input mode and I have connected a differential input signal, but my readings are random and drift rapidly. What's wrong?

Check your ground-reference connections. Your signal can be referenced to a level that is considered *floating* with reference to the device ground reference. Even if you are in differential mode, you must still reference the signal to the same ground level as the board reference. There are various methods of achieving this while maintaining a high common-mode rejection ratio (CMRR). These methods are outlined in Chapter 4, *Signal Connections*.

I'm using the DACs to generate a waveform, but I discovered with a digital oscilloscope that there are glitches on the output signal. Is this normal?

When it switches from one voltage to another, any DAC produces glitches due to released charges. The largest glitches occur when the most significant bit (MSB) of the D/A code switches. You can build a lowpass

deglitching filter to remove some of these glitches, depending on the frequency and nature of your output signal.

Can I synchronize a one-channel analog input data acquisition with a one-channel analog output waveform generation on my PCI E Series device?

Yes. One way to accomplish this is to use the waveform generation timing pulses to control the analog input data acquisition. To do this, follow steps 1 through 4 below, in addition to the usual steps for data acquisition and waveform generation configuration.

1. Enable the PFI5 line for output, as follows:
   - If you are using NI-DAQ, call `Select_Signal(deviceNumber, ND_PFI_5, ND_OUT_UPDATE, ND_HIGH_TO_LOW).`
   - If you are using LabVIEW, invoke the Route Signal VI with the signal name set to PFI5 and the signal source set to AO Update.
2. Set up data acquisition timing so that the timing signal for A/D conversion comes from PFI5, as follows:
   - If you are using NI-DAQ, call `Select_Signal(deviceNumber, ND_IN_CONVERT, ND_PFI_5, ND_HIGH_TO_LOW).`
   - If you are using LabVIEW, invoke AI Clock Config VI with clock source code set to PFI pin, high to low, and clock source string set to 5.
3. Initiate analog input data acquisition, which starts only when the analog output waveform generation starts.
4. Initiate analog output waveform generation.

Timing and Digital I/O

What types of triggering can be hardware-implemented on my device?

Digital triggering is hardware-supported on every device.

Will the counter/timer applications that I wrote previously work with the DAQ-STC?

If you are using NI-DAQ with LabVIEW, some of your applications drawn using the CTR VIs will still run. However, there are many differences in the counters between the E Series and other devices; the counter numbers are different, timebase selections are different, and the DAQ-STC counters are

24-bit counters (unlike the 16-bit counters on devices without the DAQ-STC).

If you are using the NI-DAQ language interface or LabWindows/CVI, the answer is no, the counter/timer applications that you wrote previously will not work with the DAQ-STC. You must use the GPCTR functions; ICTR and CTR functions will not work with the DAQ-STC. The GPCTR functions have the same capabilities as the ICTR and CTR functions, plus more, but you must rewrite the application with the GPCTR function calls.

I am using one of the general-purpose counter/timers on my device, but I do not see the counter/timer output on the I/O connector. What am I doing wrong?

If you are using the NI-DAQ language interface or LabWindows/CVI, you must configure the output line to output the signal to the I/O connector. Use the `Select_Signal` call in NI-DAQ to configure the output line. By default, all timing I/O lines except EXTSTROBE* are high impedance.

What are the PFIs and how do I configure these lines?

PFIs are programmable function inputs. These lines serve as connections to virtually all internal timing signals. If you are using the NI-DAQ language interface or LabWindows/CVI, use the `Select_Signal` function to route internal signals to the I/O connector, route external signals to internal timing sources, or tie internal timing signals together.

If you are using NI-DAQ with LabVIEW and you want to connect external signal sources to the PFI lines, you can use AI Clock Config, AI Trigger Config, AO Clock Config, AO Trigger and Gate Config, CTR Mode Config, and CTR Pulse Config advanced level VIs to indicate which function the connected signal serves. Use the Route Signal VI to enable the PFI lines to output internal signals.

Caution If you enable a PFI line for output, do not connect any external signal source to it; if you do, you can damage the device, the computer, and the connected equipment.

What are the power-on states of the PFI and DIO lines on the I/O connector?

At system power-on and reset, both the PFI and DIO lines are set to high impedance by the hardware. This means that the device circuitry is not actively driving the output either high or low. However, these lines can have pull-up or pull-down resistors connected to them as shown in Table 4-3, *I/O Signal Summary*. These resistors weakly pull the output to either a logic high or logic low state. For example, DIO(0) is in the high impedance state

after power on, and Table 4-3, *I/O Signal Summary*, shows that there is a 50 kΩ pull-up resistor. This pull-up resistor sets the DIO(0) pin to a logic high when the output is in a high impedance state.

D

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meanings	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}
t-	tera-	10^{12}

Numbers/Symbols

°	degree
>	greater than
<	less than
–	negative of, or minus
Ω	ohm
/	per
%	percent
±	plus or minus
+	positive of, or plus
$\sqrt{\ }$	square root of
+5 V	+5 VDC source signal

A

A	amperes
AC	alternating current
ACH	analog input channel signal
A/D	analog-to-digital
ADC	analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
ADC resolution	the resolution of the ADC, which is measured in bits. An ADC with 16 bits has a higher resolution, and thus a higher degree of accuracy, than a 12-bit ADC.
AI	analog input
AIGATE	analog input gate signal
AIGND	analog input ground signal
AISENSE	analog input sense signal
ANSI	American National Standards Institute
AO	analog output
AOGND	analog output ground signal
ASIC	Application-Specific Integrated Circuit—a proprietary semiconductor component designed and manufactured to perform a set of specific functions for a specific customer

B

base address	a memory address that serves as the starting address for programmable registers. All other addresses are located by adding to the base address.
bipolar	a voltage range spanning both negative and positive voltages
breakdown voltage	the voltage high enough to cause breakdown of optical isolation, semiconductors, or dielectric materials. *Also see* working voltage.

bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion interface to which I/O or other devices are connected. Examples of PC buses are the ISA bus and PCI bus.
bus master	a type of a plug-in board or controller with the ability to read and write devices on the computer bus

C

C	Celsius
CH	channel
channel	pin or wire lead to which you apply, or from which you read, an analog or digital signal. Analog signals can be single-ended or differential. For digital signals, channels are grouped to form ports.
CMRR	common-mode rejection ratio—a measure of the ability of a differential amplifier to reject interference from a common-mode signal, usually expressed in decibels (dB)
CONVERT*	convert signal
counter/timer	a circuit that counts external pulses or clock pulses (timing)
crosstalk	an unwanted signal on one channel due to an input on a different channel
CTR	counter
current drive capability	the amount of current a digital or analog output channel is capable of sourcing or sinking while still operating within voltage range specifications

D

D/A	digital-to-analog
DAC	D/A converter—an electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current
DAC0OUT	analog channel 0 output signal
DAC1OUT	analog channel 1 output signal

DAQ	data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and processing the measurement data using a computer; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB=20log10 V1/V2, for signals in volts
DC	direct current
DGND	digital ground signal
DIFF	differential input configuration
differential amplifier	an amplifier with two input terminals, neither of which are tied to a ground reference, whose voltage difference is amplified
differential input	the two-terminal input to a differential amplifier
DIO	digital input/output
dithering	the addition of Gaussian noise to an analog input signal
DMA	direct memory access—a method by which data can be transferred to/from computer memory from/to a device or memory on the bus while the processor does something else. DMA is the fastest method of transferring data to/from computer memory.
DNL	differential nonlinearity—a measure in LSB of the worst-case deviation of code widths from their ideal value of 1 LSB
DO	digital output
drivers/driver software	software that controls a specific hardware device such as a DAQ device

E

EEPROM	electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed. Some SCXI modules contain an EEPROM to store measurement-correction coefficients.

electrostatically coupled	propagating a signal by means of a varying electric field
EXTSTROBE	external strobe signal

F

FIFO	first-in first-out memory buffer
floating signal sources	signal sources with voltage signals that are not connected to an absolute reference or system ground. Also called nonreferenced signal sources. Some common example of floating signal sources are batteries, transformers, or thermocouples.
FREQ_OUT	frequency output signal
ft	feet

G

g	grams
gain	the factor by which a signal is amplified, sometimes expressed in decibels
GATE	gate signal
glitch	an unwanted momentary deviation from a desired signal
GPCTR	general purpose counter
GPCTR0_GATE	general purpose counter 0 gate signal
GPCTR0_OUT	general purpose counter 0 output signal
GPCTR0_SOURCE	general purpose counter 0 clock source signal
GPCTR0_UP_DOWN	general purpose counter 0 up down
GPCTR1_GATE	general purpose counter 1 gate signal
GPCTR1_OUT	general purpose counter 1 output signal
GPCTR1_SOURCE	general purpose counter 1 clock source signal

GPCTR1_UP_DOWN	general purpose counter 1 up down
GPIB	General Purpose Interface bus, synonymous with HP-IB. The standard bus used for controlling electronic instruments with a computer. Also called IEEE 488 bus because it is defined by ANSI/IEEE Standards 488-1978, 488.1-1987, and 488.2-1987.
grounded measurement system	*See* RSE.

H

h	hour
hex	hexadecimal
Hz	hertz—cycles per second of a periodic signal

I

INL	integral nonlinearity—a measure in LSB of the worst-case deviation from the ideal A/D or D/A transfer characteristic of the analog I/O circuitry
input bias current	the current that flows into the inputs of a circuit
input impedance	the measured resistance and capacitance between the input terminals of a circuit
input offset current	the difference in the input bias currents of the two inputs of an instrumentation amplifier
instrumentation amplifier	a very accurate differential amplifier with a high input impedance
interrupt	a computer signal indicating that the CPU should suspend its current task to service a designated activity
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
I_{OH}	current, output high

I_{OL}	current, output low
IRQ	interrupt request

K

k	kilo—the standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters
K	kilo—the prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory
kS	1,000 samples

L

LabVIEW	laboratory virtual instrument engineering workbench
LED	light-emitting diode
library	a file containing compiled object modules, each comprised of one of more functions, that can be linked to other object modules that make use of these functions. NIDAQMSC.LIB is a library that contains NI-DAQ functions. The NI-DAQ function set is broken down into object modules so that only the object modules that are relevant to your application are linked in, while those object modules that are not relevant are not linked.
linearity	the adherence of device response to the equation R = KS, where R = response, S = stimulus, and K = a constant
LSB	least significant bit

M

MIO	multifunction I/O
MSB	most significant bit

N

NI-DAQ	National Instruments driver software for DAQ hardware
noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.
NRSE	nonreferenced single-ended mode—all measurements are made with respect to a common measurement system reference, but the voltage at this reference can vary with respect to the measurement system ground

O

OUT	output pin—a counter output pin where the counter can generate various TTL pulse waveforms

P

PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. It is achieving widespread acceptance as a standard for PCs and work-stations; it offers a theoretical maximum transfer rate of 132 Mbytes/s.
PFI	programmable function input
PFI0/TRIG1	PFI0/trigger 1
PFI1/TRIG2	PFI1/trigger 2
PFI2/CONVERT*	PFI2/convert
PFI3/GPCTR1_ SOURCE	PFI3/general purpose counter 1 source
PFI4/GPCTR1_GATE	PFI4/general purpose counter 1 gate
PFI5/UPDATE*	PFI5/update
PFI6/WFTRIG	PFI6/waveform trigger

PFI7/STARTSCAN	PFI7/start of scan
PFI8/GPCTR0_ SOURCE	PFI8/general purpose counter 0 source
PFI9/GPCTR0_GATE	PFI9/general purpose counter 0 gate
PGIA	programmable gain instrumentation amplifier
port	(1) a digital port consisting of multiple I/O lines on a DAQ device (2) a serial or parallel interface connector on a PC
PPI	programmable peripheral interface
ppm	parts per million
pu	pullup
pulse trains	multiple pulses

Q

quantization error	the inherent uncertainty in digitizing an analog value due to the finite resolution of the conversion process

R

referenced signal sources	signal sources with voltage signals that are referenced to a system ground, such as the earth or a building ground. Also called grounded signal sources.
resolution	the smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244% of full scale.
ribbon cable	a flat cable in which the conductors are side by side
rise time	the difference in time between the 10% and 90% points of a system's step response
rms	root mean square—the square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude

RSE	referenced single-ended mode—all measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system.
RTSI bus	real-time system integration bus—the National Instruments timing bus that connects DAQ devices directly, by means of connectors on top of the devices, for precise synchronization of functions

S

s	seconds
S	samples
sample counter	the clock that counts the output of the channel clock, in other words, the number of samples taken. On boards with simultaneous sampling, this counter counts the output of the scan clock and hence the number of scans.
scan	one or more analog samples taken at the same time, or nearly the same time. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one scan, acquires one new sample from every analog input channel in the group.
scan clock	the clock controlling the time interval between scans.
scan rate	the number of scans a system takes during a given time period, usually expressed in scans per second
SCXI	Signal Conditioning eXtensions for Instrumentation
SE	single-ended—a term used to describe an analog input that is measured with respect to a common ground
self-calibrating	a property of a DAQ board that has an extremely stable onboard reference and calibrates its own A/D and D/A circuits without manual adjustments by the user
sensor	a device that converts a physical phenomenon into an electrical signal
settling time	the amount of time required for a voltage to reach its final value within specified accuracy limits
signal conditioning	the manipulation of signals to prepare them for digitizing

SISOURCE	SI counter clock signal
software trigger	a programmed event that triggers an event such as data acquisition
software triggering	a method of triggering in which you simulate an analog trigger using software. Also called conditional retrieval.
SOURCE	source signal
S/s	samples per second—used to express the rate at which a DAQ board samples an analog signal
STARTSCAN	start scan signal
STC	system timing controller
synchronous	(1) hardware—a property of an event that is synchronized to a reference clock (2) software—a property of a function that begins an operation and returns only when the operation is complete

T

TC	terminal count—the highest value of a counter
THD	total harmonic distortion
THD+N	signal-to-THD plus noise—the ratio in decibels of the overall rms signal to the rms signal of harmonic distortion plus noise introduced
TRIG	trigger signal
trigger	any event that causes or starts some form of data capture
TTL	transistor-transistor logic

U

UI	update interval
unipolar	a signal range that is always positive (for example, 0 to +10 V)
UISOURCE	update interval counter clock signal

update	the output equivalent of a scan. One or more analog or digital output samples. Typically, the number of output samples in an update is equal to the number of channels in the output group. For example, one pulse from the update clock produces one update which sends one new sample to every analog output channel in the group.
update rate	the number of output updates per second

V

V	volts
Vcc	positive supply voltage
VDC	volts direct current
VI	virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program
V_{IH}	volts, input high
V_{IL}	volts, input low
V_{in}	volts in
V_m	measured voltage
V_{OH}	volts, output high
V_{OL}	volts, output low
V_{ref}	reference voltage
V_{rms}	volts, root mean square

W

waveform	multiple voltage readings taken at a specific sampling rate
WFTRIG	waveform generation trigger signal
working voltage	the highest voltage that should be applied to a product in normal use, normally well under the breakdown voltage for safety margin. *See also* breakdown voltage.

Index

Numbers

+5 V signal
  description (table), 4-4
  self-resetting fuse, C-1
82C55A Programmable Peripheral Interface. *See* PPI (Programmable Peripheral Interface).
6023E/6024E/6025E devices. *See also* hardware overview; specifications.
  block diagram, 3-1
  features, 1-1 to 1-2
  optional equipment, 1-5 to 1-6
  requirements for getting started, 1-2 to 1-3
  software programming choices, 1-3 to 1-5
    National Instruments application software, 1-3 to 1-4
    NI-DAQ driver software, 1-4 to 1-5
  unpacking, 2-1
  using PXI with CompactPCI, 1-2

A

ACH<0..15> signal
  description (table), 4-4
  signal summary (table), 4-7
ACK* signal
  description (table), 4-26
  mode 1 output timing (figure), 4-28
  mode 2 bidirectional timing (figure), 4-29
acquisition timing connections. *See* DAQ timing connections.
AIGATE signal, 4-39
AIGND signal
  analog input mode, 4-10
  description (table), 4-4
  signal summary (table), 4-7
AISENSE signal
  description (table), 4-4
  NRSE mode, 4-10
  signal summary (table), 4-7
analog input
  available input configurations (table), 3-3
  common questions, C-2 to C-3
  dithering, 3-4 to 3-5
  input modes, 3-2 to 3-3
  input range, 3-3
  multichannel scanning considerations, 3-5 to 3-6
analog input signal connections, 4-8 to 4-19
  common-mode signal rejection considerations, 4-19
  differential connections, 4-13 to 4-16
    ground-referenced signal sources, 4-14
    nonreferenced or floating signal sources, 4-15 to 4-16
  exceeding common-mode input ranges (caution), 4-10
  PGIA (figure), 4-10
  recommended input connections (figure), 4-12
  single-ended connection, 4-17 to 4-19
    floating signal sources (RSE configuration), 4-18
    grounded signal sources (NRSE configuration), 4-18 to 4-19
  summary of input connections (table), 4-12
  types of signal sources, 4-8 to 4-9
    floating signal sources, 4-9
    ground-referenced signal sources, 4-9
analog input specifications
  PCI and PXI buses, A-1 to A-4
    accuracy information, A-2
    amplifier characteristics, A-3

dynamic characteristics, A-4
input characteristics, A-1 to A-2
stability, A-4
transfer characteristics, A-3
PCMCIA bus, A-11 to A-14
accuracy information, A-12
amplifier characteristics, A-13
dynamic characteristics, A-13
input characteristics, A-11
stability, A-13 to A-14
transfer characteristics, A-12
analog output
analog output glitch, 3-6
common questions, C-2 to C-3
overview, 3-6
signal connections, 4-19 to 4-20
analog output specifications
PCI and PXI buses, A-4 to A-6
accuracy information, A-5
dynamic characteristics, A-6
output characteristics, A-4 to A-5
stability, A-6
transfer characteristics, A-5
voltage output, A-6
PCMCIA bus, A-14 to A-16
accuracy information, A-14
dynamic characteristics, A-15
output characteristics, A-14
stability, A-16
transfer characteristics, A-14 to A-15
voltage output, A-15
AOGND signal
analog output signal connections, 4-19 to 4-20
description (table), 4-4
signal summary (table), 4-7

B

bipolar input, 3-3
block diagrams
6023E/6024E/6025E devices, 3-1
DAQCard-6024E, 3-2

C

cables. *See also* I/O connectors.
custom cabling, B-1 to B-2
field wiring considerations, 4-49
optional equipment, 1-5
calibration, 5-1 to 5-3
adjusting gain error, 5-3
external calibration, 5-2
loading calibration constants, 5-1 to 5-2
self-calibration, 5-2
specifications
PCI and PXI buses, A-9
PCMCIA bus, A-17
charge injection, 3-6
clocks, device and RTSI, 3-9
commonly asked questions. *See* questions and answers.
common-mode signal rejection considerations, 4-19
CompactPCI products, using with PXI, 1-2
configuration
common questions, C-2
hardware configuration, 2-3
connectors. *See* I/O connectors.
conventions used in manual, *xi-xii*
CONVERT* signal
DAQ timing connections, 4-38 to 4-39
signal routing (figure), 3-8
custom cabling, B-1 to B-2
customer education, D-1

D

DAC0OUT signal
analog output signal connections, 4-19 to 4-20
description (table), 4-4
signal summary (table), 4-7
DAC1OUT signal
analog output signal connections, 4-19 to 4-20
description (table), 4-4
signal summary (table), 4-7
DAQ timing connections, 4-32 to 4-40
AIGATE signal, 4-39
CONVERT* signal, 4-38 to 4-39
EXTSTROBE* signal, 4-33 to 4-34
SCANCLK signal, 4-33
SISOURCE signal, 4-40
STARTSCAN signal, 4-36 to 4-38
TRIG1 signal, 4-34 to 4-35
TRIG2 signal, 4-35 to 4-36
typical posttriggered acquisition (figure), 4-32
typical pretriggered acquisition (figure), 4-33
DAQCard-6024E block diagram, 3-2
DAQ-STC, C-1
DATA signal
description (table), 4-26
mode 1 input timing (figure), 4-27
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
device and RTSI clocks, 3-9
DGND signal
description (table), 4-4
digital I/O signal connections, 4-20 to 4-21
signal summary (table), 4-7
DIFF mode
description (table), 3-3
recommended configuration (figure), 4-12
differential connections, 4-13 to 4-16
ground-referenced signal sources, 4-14
nonreferenced or floating signal sources, 4-15 to 4-16
when to use, 4-13
digital I/O. *See also* PPI (Programmable Peripheral Interface).
common questions, C-3 to C-5
overview, 3-7
signal connections, 4-20 to 4-22
block diagram of digital I/O connections (figure), 4-22
digital I/O connections (figure), 4-21
digital I/O specifications
PCI and PXI buses, A-7 to A-8
DIO<0..7>, A-7
PA<0..7>, PB<0..7>, PC<0..7>, A-7
PCMCIA bus, A-16
DIO<0..7>, A-16
digital trigger specifications, A-9
DIO power-up state, changing to pulled low, 4-24 to 4-25
DIO<0..7> signal
description (table), 4-4
digital I/O signal connections, 4-20 to 4-21
digital I/O specifications, A-7
signal summary (table), 4-7
dithering, 3-4 to 3-5
documentation
conventions used in manual, *xi-xii*
related documentation, *xii*

E

EEPROM storage of calibration constants, 5-1
environment specifications
PCI and PXI buses, A-10
PCMCIA bus, A-18
environmental noise, 4-49
equipment, optional, 1-5 to 1-6

EXTSTROBE* signal
DAQ timing connections, 4-33 to 4-34
description (table), 4-5
signal summary (table), 4-7

F

field wiring considerations, 4-49
floating signal sources
description, 4-9
differential connections, 4-15 to 4-16
single-ended connections (RSE configuration), 4-18
FREQ_OUT signal
description (table), 4-6
general-purpose timing signal connections, 4-49
signal summary (table), 4-8
frequently asked questions. *See* questions and answers.
fuse, self-resetting, C-1

G

gain error, adjusting, 5-3
general-purpose timing signal connections, 4-43 to 4-49
FREQ_OUT signal, 4-49
GPCTR0_GATE signal, 4-44 to 4-45
GPCTR0_OUT signal, 4-45
GPCTR0_SOURCE signal, 4-43 to 4-44
GPCTR0_UP_DOWN signal, 4-45
GPCTR1_GATE signal, 4-46 to 4-47
GPCTR1_OUT signal, 4-47
GPCTR1_SOURCE signal, 4-46
GPCTR1_UP_DOWN signal, 4-47 to 4-49
glitch, analog output, 3-6
GPCTR0_GATE signal, 4-44 to 4-45
GPCTR0_OUT signal
description (table), 4-6
general-purpose timing signal connections, 4-45
signal summary (table), 4-8
GPCTR0_SOURCE signal, 4-43 to 4-44
GPCTR0_UP_DOWN signal, 4-45
GPCTR1_GATE signal, 4-46 to 4-47
GPCTR1_OUT signal
description (table), 4-5
general-purpose timing signal connections, 4-47
signal summary (table), 4-8
GPCTR1_SOURCE signal, 4-46
GPCTR1_UP_DOWN signal, 4-47 to 4-49
ground-referenced signal sources
description, 4-9
differential connections, 4-14
single-ended connections (NRSE configuration), 4-18 to 4-19

H

hardware
configuration, 2-3
installation, 2-2 to 2-3
hardware overview
analog input, 3-2 to 3-6
dithering, 3-4 to 3-5
input modes, 3-2 to 3-3
input range, 3-3
analog output, 3-6
block diagram
6023E/6024E/6025E devices, 3-1
DAQCard-6024E, 3-2
digital I/O, 3-7
timing signal routing, 3-7 to 3-11
device and RTSI clocks, 3-9
programmable function inputs, 3-8 to 3-9
RTSI triggers, 3-9 to 3-11

I

IBF signal
description (table), 4-25
mode 1 input timing (figure), 4-27
mode 2 bidirectional timing (figure), 4-29
input modes, 3-2 to 3-3. *See also* analog input.
input range
exceeding common-mode input ranges (caution), 4-10
measurement precision (table), 3-3
overview, 3-3
installation
common questions, C-2
hardware, 2-2 to 2-3
software, 2-1
unpacking 6023E/6024E/6025E, 2-1
INTR signal
description (table), 4-26
mode 1 input timing (figure), 4-27
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
I/O connectors, 4-1 to 4-8
exceeding maximum ratings (warning), 4-1
I/O connector details (table), 4-1
optional connectors, B-2 to B-6
50-pin E Series connector pin assignments (figure), B-5
50-pin extended digital input connector pin assignments (figure), B-6
68-pin E Series connector pin assignments (figure), B-3
68-pin extended digital input connector pin assignments (figure), B-4
pin assignments (table)
6023E/6024E, 4-2
6025E, 4-3

L

LabVIEW and LabWindows/CVI application software, 1-3 to 1-4

M

manual. *See* documentation.
Measurement Studio software, 1-3 to 1-4
mode 1 input timing (figure), 4-27
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
multichannel scanning
considerations, 3-5 to 3-6

N

NI Developer Zone, D-1
NI-DAQ driver software, 1-4 to 1-5
noise, environmental, 4-49
NRSE (nonreferenced single-ended) mode
configuration, 4-9 to 4-10
description (table), 3-3
differential connections, 4-15 to 4-16
recommended configuration (figure), 4-12
single-ended connections for ground-referenced signal sources, 4-18 to 4-19

O

OBF* signal
description (table), 4-26
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
operating environment specifications
PCI and PXI buses, A-10
PCMCIA bus, A-18
optional equipment, 1-5 to 1-6

P

PA<0..7> signal
description (table), 4-4
digital I/O specifications, A-7
signal summary (table), 4-7
PB<0..7> signal
description (table), 4-4
digital I/O specifications, A-7
signal summary (table), 4-7
PC<0..7> signal
description (table), 4-4
digital I/O specifications, A-7
signal summary (table), 4-7
PCI and PXI bus specifications. *See* specifications.
PCMCIA bus specifications. *See* specifications.
PFI0/TRIG1 signal
description (table), 4-5
signal summary (table), 4-7
PFI1/TRIG2 signal
description (table), 4-5
signal summary (table), 4-7
PFI2/CONVERT* signal
description (table), 4-5
signal summary (table), 4-7
PFI3/GPCTR1_SOURCE signal
description (table), 4-5
signal summary (table), 4-7
PFI4/GPCTR1_GATE signal
description (table), 4-5
signal summary (table), 4-8
PFI5/UPDATE signal
description (table), 4-6
signal summary (table), 4-8
PFI6/WFTRIG signal
description (table), 4-6
signal summary (table), 4-8
PFI7/STARTSCAN signal
description (table), 4-6
signal summary (table), 4-8
PFI8/GPCTR0_SOURCE signal
description (table), 4-6
signal summary (table), 4-8
PFI9/GPCTR0_GATE signal
description (table), 4-6
signal summary (table), 4-8
PFIs (programmable function inputs)
common questions, C-4 to C-5
signal routing, 3-8 to 3-9
timing connections, 4-31 to 4-32
PGIA (programmable gain instrumentation amplifier)
analog input modes, 4-9 to 4-11
differential connections
ground-referenced signal sources (figure), 4-14
nonreferenced or floating signal sources, 4-15 to 4-16
single-ended connections
floating signal sources (figure), 4-18
ground-referenced signal sources (figure), 4-19
physical specifications
PCI and PXI buses, A-9 to A-10
PCMCIA bus, A-18
pin assignments
6023E/6024E (figure), 4-2
6025E (figure), 4-3
Port C pin assignments
description, 4-23
signal assignments (table), 4-23
posttriggered acquisition (figure), 4-32
power connections, 4-30
power requirement specifications
PCI and PXI buses, A-9
PCMCIA bus, A-17

power-up state, digital I/O, 4-24 to 4-25
PPI (Programmable Peripheral Interface)
6025E only, 4-22 to 4-23
changing DIO power-up state to pulled low, 4-24 to 4-25
digital I/O connections block diagram (figure), 4-22
mode 1 input timing (figure), 4-27
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
Port C pin assignments, 4-23
power-up state, 4-24 to 4-25
signal names used in diagrams (table), 4-25 to 4-26
timing specifications, 4-25 to 4-29
pretriggered acquisition (figure), 4-33
programmable function inputs (PFIs). *See* PFIs (programmable function inputs).
programmable gain instrumentation amplifier. *See* PGIA (programmable gain instrumentation amplifier).
Programmable Peripheral Interface (PPI). *See* PPI (Programmable Peripheral Interface).
PXI products, using with CompactPCI, 1-2

Q

questions and answers, C-1 to C-5
analog input and output, C-2 to C-3
general information, C-1
installation and configuration, C-2
timing and digital I/O, C-3 to C-5

R

RD* signal
description (table), 4-26
mode 1 input timing (figure), 4-27
mode 2 bidirectional timing (figure), 4-29
referenced single-ended input (RSE). *See* RSE (referenced single-ended) mode.
requirements for getting started, 1-2 to 1-3
RSE (referenced single-ended) mode
configuration, 4-9 to 4-10
description (table), 3-3
recommended configuration (figure), 4-12
single-ended connections for floating signal sources, 4-18
RTSI clocks, 3-9
RTSI trigger lines
overview, 3-9
signal connection
PCI devices (figure), 3-10
PXI devices (figure), 3-11
PXI E series devices (figure), 3-11
specifications, A-9

S

sampling rate, C-1
SCANCLK signal
DAQ timing connections, 4-33
description (table), 4-5
signal summary (table), 4-7
scanning, multichannel, 3-5 to 3-6
settling time, in multichannel scanning, 3-6
signal connections
analog input, 4-8 to 4-19
common-mode signal rejection considerations, 4-19
differential connection considerations, 4-13 to 4-16
input modes, 4-9 to 4-11
single-ended connection considerations, 4-17 to 4-19
summary of input connections (table), 4-12
types of signal sources, 4-8 to 4-9

analog output, 4-19 to 4-20
digital I/O, 4-20 to 4-22
field wiring considerations, 4-49
I/O connectors, 4-1 to 4-8
exceeding maximum ratings (warning), 4-1
I/O connector details (table), 4-1
I/O connector signal descriptions (table), 4-4 to 4-6
I/O signal summary (table), 4-7 to 4-8
pin assignments (figure), 4-2 to 4-3
I/O connectors, optional, B-2 to B-6
50-pin E Series connector pin assignments (figure), B-5
50-pin extended digital input connector pin assignments (figure), B-6
68-pin E Series connector pin assignments (figure), B-3
68-pin extended digital input connector pin assignments (figure), B-4
power connections, 4-30
Programmable Peripheral Interface
6025E only, 4-22 to 4-23
mode 1 input timing (figure), 4-27
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
Port C pin assignments, 4-23
power-up state, 4-24 to 4-25
signal names used in diagrams (table), 4-25 to 4-26
timing specifications, 4-25 to 4-29
timing connections, 4-30 to 4-49
DAQ timing connections, 4-32 to 4-40
general-purpose timing signal connections, 4-43 to 4-49
programmable function input connections, 4-31 to 4-32
waveform generation timing connections, 4-40 to 4-43
signal sources, 4-8 to 4-9
floating signal sources, 4-9
ground-referenced signal sources, 4-9
single-ended connections, 4-17 to 4-19
floating signal sources (RSE configuration), 4-18
grounded signal sources (NRSE configuration), 4-18 to 4-19
when to use, 4-17
SISOURCE signal, 4-40
software installation, 2-1
software programming choices, 1-3 to 1-5
LabVIEW and LabWindows/CVI, 1-3 to 1-4
Measurement Studio software, 1-3 to 1-4
National Instruments application software, 1-3 to 1-4
NI-DAQ driver software, 1-4 to 1-5
VirtualBench, 1-4
specifications
PCI and PXI buses
analog input, A-1 to A-4
analog output, A-4 to A-6
calibration, A-9
digital I/O, A-7 to A-8
operating environment, A-10
physical, A-9 to A-10
power requirement, A-9
storage environment, A-10
timing I/O, A-8
triggers, A-9
PCMCIA bus, A-11 to A-18
analog input, A-11 to A-14
analog output, A-14 to A-16
calibration, A-17
digital I/O, A-16
environment, A-18

physical, A-18
power requirements, A-17
timing I/O, A-16 to A-17
triggers, A-17
STARTSCAN signal, 4-36 to 4-38
STB* signal
description (table), 4-25
mode 1 input timing (figure), 4-27
mode 2 bidirectional timing (figure), 4-29
storage environment specifications, PCI and PXI buses, A-10
system integration, by National Instruments, D-1

T

technical support resources, D-1
timing connections, 4-30 to 4-49
DAQ timing connections, 4-32 to 4-40
AIGATE signal, 4-39
CONVERT* signal, 4-38 to 4-39
EXTSTROBE* signal, 4-33 to 4-34
SCANCLK signal, 4-33
SISOURCE signal, 4-40
STARTSCAN signal, 4-36 to 4-38
TRIG1 signal, 4-34 to 4-35
TRIG2 signal, 4-35 to 4-36
typical posttriggered acquisition (figure), 4-32
typical pretriggered acquisition (figure), 4-33
general-purpose timing signal connections, 4-43 to 4-49
FREQ_OUT signal, 4-49
GPCTR0_GATE signal, 4-44 to 4-45
GPCTR0_OUT signal, 4-45
GPCTR0_SOURCE signal, 4-43 to 4-44
GPCTR0_UP_DOWN signal, 4-45
GPCTR1_GATE signal, 4-46 to 4-47
GPCTR1_OUT signal, 4-47
GPCTR1_SOURCE signal, 4-46
GPCTR1_UP_DOWN signal, 4-47 to 4-49
overview, 4-30
programmable function input connections, 4-31 to 4-32
timing I/O connections (figure), 4-31
waveform generation timing connections, 4-40 to 4-43
UISOURCE signal, 4-42 to 4-43
UPDATE* signal, 4-41 to 4-42
WFTRIG signal, 4-40 to 4-41
timing I/O
common questions, C-3 to C-5
specifications
PCI and PXI buses, A-8
PCMCIA bus, A-16 to A-17
timing signal routing, 3-7 to 3-11
CONVERT* signal routing (figure), 3-8
device and RTSI clocks, 3-9
programmable function inputs, 3-8 to 3-9
RTSI triggers, 3-9 to 3-11
timing specifications, 4-25 to 4-29
mode 1 input timing (figure), 4-27
mode 1 output timing (figure), 4-28
mode 2 bidirectional timing (figure), 4-29
signal names used in diagrams (table), 4-25 to 4-26
TRIG1 signal, 4-34 to 4-35
TRIG2 signal, 4-35 to 4-36
trigger specifications
PCI and PXI buses
digital trigger, A-9
RTSI trigger, A-9
PCMCIA bus, A-17
digital trigger, A-17
triggers, RTSI. *See* RTSI trigger lines.

U

UISOURCE signal, 4-42 to 4-43
unpacking 6023E/6024E/6025E, 2-1
UPDATE* signal, 4-41 to 4-42

V

VCC signal (table), 4-7
VirtualBench software, 1-4
voltage output specifications
    PCI and PXI buses, A-6
    PCMCIA bus, A-15

W

waveform generation, questions
  about, C-2 to C-3
waveform generation timing
  connections, 4-40 to 4-43
    UISOURCE signal, 4-42 to 4-43
    UPDATE* signal, 4-41 to 4-42
    WFTRIG signal, 4-40 to 4-41
Web support from National Instruments, D-1
WFTRIG signal, 4-40 to 4-41
Worldwide technical support, D-2
WR* signal
    description (table), 4-26
    mode 1 output timing (figure), 4-28
    mode 2 bidirectional timing (figure), 4-29

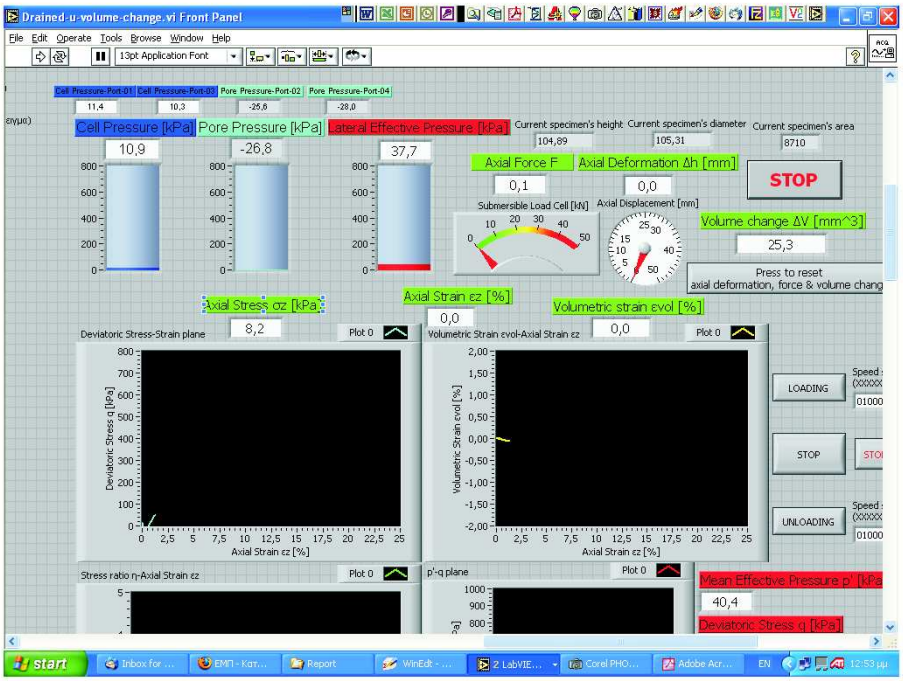


Figure 4.10: The Labview v.7.1 interface

4.3 The data acquisition program

Having all the above components successfully installed, the analog signal from the transducers is converted into digital, and the computer is able to proceed with the data manipulation. The last piece of the puzzle is an acquisition program that will allow for the manipulation of the stored data during and after the test. For this purpose, NI Labview 7.1© is the data acquisition program installed. Its graphical interface, including evolution graphs, leds, buttons, control and display strings etc., allows for synchronous to the testing time and visual interpretation of the measured properties of the test.

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